CHAPTER 4. NORTHERN PACIFIC OCEANIC OPERATIONS

1. THE NOPAC SYSTEM.

a. General. Due to increases in passenger demand, time zone differences, airport noise restrictions, and other factors, most Northern Pacific (NOPAC) air traffic is concentrated in predictable flow patterns. The effect of these flows is that eastbound traffic peaks between 0800 coordinated universal time (UTC) and 2000 UTC, and westbound traffic peaks between 2200 UTC and 0800 UTC. During peak periods, airspace becomes congested due to the limitations of the lateral and longitudinal separation required. This is compounded by winds aloft and route distances. The long route distances add to the critical aspects of the airspace because climb approval and altitude availability may necessitate in-flight decisions concerning destination. The most critical altitudes are flight levels (FL) 310 to 410.

b. Composite Route System. To more adequately meet present and future demands, the NOPAC Composite Route System was implemented in March 1982 to maximize use of available airspace while providing a safe and orderly traffic flow. The composite route system is comprised of five air traffic service (ATS) routes that travel the NOPAC between Alaska and Japan. The two northern routes are used for westbound traffic except for R580, which is used for eastbound traffic transiting the Tokyo/Anchorage flight information region (FIR) between 1000 UTC and 1700 UTC. The three southern routes are used for eastbound traffic, except that A590 is used for westbound aircraft crossing the Tokyo/Anchorage FIR between 2300 UTC and 0500 UTC when R220 and R580 traffic is saturated. The system allows a combination of 50 nautical miles (NM) lateral separation and 1,000 feet vertical separation on immediately adjacent routes. By management of route and altitude assignments, any aircraft at the same altitude and not longitudinally separated are laterally separated by at least 100 NM. Any aircraft on the same route are separated by 2,000 feet vertically or 20 minutes longitudinally. The longitudinal separation can be reduced to 10 minutes or less when mach techniques are applied. Standard oceanic (noncomposite) separation is used elsewhere unless radar services are provided or aircraft are within domestic control areas where domestic nonradar control procedures are used. A sample of a composite route, with latitude/longitude coordinates of reporting points and magnetic bearings and distances between them, follows:

Route R220

- BETHEL VORTAC - 239° 312 NM 057° -
- NABIE (N59°18.0' W171°45.4') - 237° 3296 NM 056° -
- NUKKS (N57°15.1' E179°44.3') - 237° 3297 NM 054° -
- NEEVA (N54°40.7' E172°11.8') - 241° 3281 NM 060° -
- NINNO (N52°21.5' E165°22.8') - 240° 3280 NM 058° -
- NIPPO (FIR boundary) (N49°41.9' E159°19.3') - 238° 3330 NM 053° -
- NYTIM (N46°11.9' E153°00.5') - 233° 3330 NM 051° -
- NOKKA (N42°23.3' E147°28.8') - 231° 3163 NM 049° -
- NOHO (N40°25.0' E145°00.0') - 231° 3122 NM 049° -
- NANAC (N38°54.2' E143°13.9')

FIGURE 4-1 LOCATION IDENTIFIERS

AKN	King Salmon, Alaska	KET	Keta, Japan
ANC	Anchorage, Alaska	MX	Matsushima, Japan
BET	Bethel, Alaska	NOH	Noho, Japan
CDB	Cold Bay, Alaska	NUD	Navy Adak, Alaska
CVC	Choshi, Japan	PDN	Port Heiden, Alaska
DLG	Dillingham, Alaska	RCTP	Taipei, China
EDF	Elmendorf AFB	RJAA	Narita, Japan
EHM	Cape Newenham, Alaska	RJSM	Misawa, Japan
EIL	Eielson AFB	RJTT	Tokyo, Japan
FAI	Fairbanks, Alaska	RJTY	Yokota, Japan
GOC	Daigo, Japan	RODN	Kadina, Japan
GTC	Niigata, Japan	SCR	Schooner
INF	Inkfish	SNL	Snail
VHHH	Hong Kong	SPY	St. Paul Island, Alaska
KCC	Nagoya, Japan	SYA	Shemya, Alaska

Samples of cross-checks that are available are shown below. Current navigation charts should be consulted for current cross-check information.

- for NEEVA on R220: SYA 328R/135 distance measuring equipment (DME)
- for ONADE on R580: SYA 328R/068 DME
- for AMMOE on R591: SYA 148R/050 DME
- for CHIPT on G344: SYA 148R/100 DME

c. ***Oceanic Transition Routes.*** Within the Tokyo FIR, oceanic transition routes (OTR) and, in one case, a Victor route, have been established for aircraft transitioning to and from the NOPAC. Within the Oakland/Anchorage FIR, certain ATS routes are used for the same purpose. Examples of some of those routes follow, in some cases including the magnetic bearings and distances between significant points:

(1) Within the Tokyo FIR, Route V51 primarily serves eastbound and westbound traffic overflying Japan. V51 routing is:

GTC (Niigata) - SDE (SENDAI) - ASTER 056° 100NM - NOGAR 065° 134NM

OTR-3 serves as a departure route from RJTY (Yokota) to A590, an arrival route to RJTY (Yokota) and RJTT (Tokyo) from R580, and for westbound traffic overflying Japan. OTR-3 routing is:

GOC (Daigo) - SNL (Snail) - Sabes - A590
R580 OATIS 250° 79NM 069° Snail - GOC (Daigo)

OTR-4 serves as a departure route from RJTY (Yokota) to A590. OTR-4 routing is:

GOC (Daigo) TOPOS - PABBA

OTR-11 serves as a departure route from RJAA (Narita) and RJTT (Tokyo) into the eastbound NOPAC routes, and for eastbound traffic overflying Japan. OTR-11 routing is:

CVC (Choshi) - KAGIS - A590
CVC (Choshi) - KAGIS - 085° 91NM 266° - ABETS - A591
CVC (Choshi) - KAGIS - SCR (Score) - COMFE - G344

(2) Within the Anchorage/Oakland control area (CTA)/FIR's, OTR-14 serves traffic departing North America and transiting the Gulf of Alaska for the NOPAC route system. OTR-14 routing is:

N54°20′ W0140°00′ - 277° 402NM 090° - MARLO (N57°27.9′ W150°31.7′) - J123 - AKN (King Salmon) - EHM (Cape Newenham) - 250° 281NM 069° - OYSTA (N58°12.9′ W170°57.4′) - 251° 305NM 069° - NUKKS (N57°15.1′ E179°44.3′) - R220

OTR-15 serves traffic departing North America and transiting the Gulf of Alaska for the NOPAC composite route system. OTR-15 routing is:

N52°30′ W140°00′ - 274° 388NM 087° - N55°05′ W150°00′ - 273° 312NM 089° - PDN (Port Heiden NDB) - 258° 379NM 074° - SPY (St. Paul Island NDB/DME) - 250° 308NM 069° - ORDON (N56°12.8′ W179°23.3′) - R580

OTR-16 serves traffic departing the United States and transiting the North Pole for the NOPAC route system. OTR-16 routing is:

N48°00′ W150°00′ - 273° 416NM 088° - N50°15′ W160°00′ - 265° 385NM 081° - N51°10′ W170°00′ - 270° 250NM 089° - NUD (Adak) - J115 - SYA (Shemya) - 255° 296NM - 073° - OMPPA (N51°26.3′ E166°20.2′) - R580

2. GENERAL PROCEDURES.

a. Climb Times. All aircraft entering the Anchorage FIR and planning a higher altitude en route should forward the time that the climb to higher altitude is desired. This information should be included with the first mandatory position report. Although most carriers include climb times in their flight plans, actual loads, weather conditions, outside air temperature, and other factors are almost always different from the forecast situation. Pilots should notify air traffic control (ATC) if the climb time differs significantly. Climb times are used by controllers to determine action that may be necessary to preclude merging air traffic conditions. Advance planning usually means better airspace use, more altitude change approvals, and better service to more users. Without accurate climb times, an altitude change for one aircraft may cause other flights to be trapped at low FL's. Traffic permitting, cruise climbs to higher en route altitudes will be approved when requested.

b. Visual Flight Rules (VFR) Climbs. Requests for VFR climbs can only be approved when the aircraft is within the confines of Control 1234/Anchorage Continental FIR or Woody Island Control Area (formerly known as Control 1235).

c. Peak Traffic Constraints. Eastbound peak traffic periods are 1000 UTC to 1800 UTC. West-bound peak traffic period is 0000 UTC to 0700 UTC. Due to traffic volume, flights desiring to operate opposite the peak traffic flow can expect to be rerouted or restricted to a low altitude. If feasible, users planning to operate in the NOPAC composite area at airspeeds below mach 0.78 should use other than the peak hours for their flights. This avoids congestion and expedites traffic.

3. FLIGHT PLANS AND PREFERRED ROUTES.

a. Flight Plans. Flightcrews operating in the composite route system are expected to carry a flight plan for each of the composite routes for the direction to be flown, plus a plan for Route A590 since that route is used for eastbound or westbound traffic at different times. This prevents unnecessary delays, since pilots may be assigned routes other than those filed in the flight plan. Flight plans should be filed according to International Civil Aviation Organization (ICAO) procedures and format. This permits automatic flight data processing at oceanic control centers and oceanic radio stations en route. Flights originating outside of Anchorage or Tokyo regions that enter oceanic airspace without intermediate stops should submit flight plans as early as possible. In addition to the normal requirements of addressing the flight plan to all oceanic control centers en route, associated oceanic radio stations should be addressed. This provides those stations with information such as flight identification, selective calling (selcal), aircraft registration, destination, and estimated time of arrival (ETA). This information is necessary to control traffic. A properly addressed flight plan that is formatted according to ICAO standards is automatically handled by oceanic centers. When planning a flight via composite routes, list the point of entry followed by the route designator and the point of exit.

b. ***Preferred Routes.*** Prior to 1300 UTC daily, users may inform Anchorage Air Route Traffic Control Center (ARTCC) by teletype of their proposed routes. Preferred ATS routes are announced daily for aircraft entering the Anchorage FIR en route to the composite route system between 2200 UTC and 0500 UTC daily. Between 1300 UTC and 1330 UTC, Anchorage ARTCC issues an international Notice to Airmen (NOTAM) that specifies the transition route that must be filed for flights planned for R220, R580, and A590.

NOTAM example: "West coast operators...the following routes are in use today between 2200 UTC and 0500 UTC for westbound aircraft entering the Anchorage FIR and transitioning to the NOPAC: for R220, B327 over MARLO; for R580, G469 over NESSY; for A590, A342 over BLOWS."

Aircraft entering the composite route system between 0400 UTC and 2000 UTC daily must file via R220. Aircraft departing Anchorage for the NOPAC route system between 2200 UTC and 0300 UTC may anticipate a restriction of 10 minutes between successive departures. Due to a route crossing in a nonradar environment, westbound arrivals destined for RJCC, RJCH, RJSM and other westbound aircraft leaving the NOPAC system by way of V51 must file via R220. R580 is an eastbound track for aircraft entering the Anchorage FIR between 1000 UTC and 1700 UTC daily. The preferred route to Alaska, Europe, midwestern United States, and U.S. east coast airports is by way of R580 - OZZIE - flight planned route.

To Alaska, Canada, U.S. west coast, midwest United States, and U.S. east coast airports:

- A590 - SPY - G469 - NESSY - flight planned route
- A590 - EMH - B327 - MARLO - flight planned route
- A590 - EHM - J996R - ANC - flight planned route

To Canada, U.S. west coast, and southwestern United States airports:

- R591 - ARGOS - G215 - DUVAL - flight planned route
- R591 - ASHER - A342 - BLOWS - flight planned route

To U.S. west coast and southwestern airports: G344-CHIPT-R451-SAVRY-flight planned route.

4. COMMUNICATIONS AND POSITION REPORTING.

a. ***High Frequency (HF) Communications.*** Most NOPAC area communications are conducted on HF single sideband. Pilots communicate with control centers through oceanic radio stations. Aircraft reports, messages and requests are relayed by the station to the appropriate ATC center by interphone, computer, or teletype. The relay function, coupled with the need for intercenter coordination, may cause delays in handling routine requests. Priority message handling procedures for urgent communications reduce time lag; however, flightcrews should consider the possibility of delays when requesting step climbs, reroutes, or other routine requests requiring action by ATC. Delays can be reduced by advance planning. Aircraft entering a FIR should establish communication with the appropriate oceanic radio station. The station will advise the aircraft of the primary and secondary HF channels in use. If possible, the aircraft should monitor both channels. If only one frequency can be monitored, the primary should be guarded and the secondary should be the first frequency checked if communication is lost on the primary. If the selcal unit is working when initial contact is made, the aircraft may maintain a selcal watch on the appropriate frequencies. If the selcal unit is inoperative or the radio station's selcal transmitter is malfunctioning, the aircraft shall maintain a listening watch on the appropriate NOPAC frequency. The NOPAC HF net operates on the following assigned frequencies: 2932 kilohertz (KHz), 5628 KHz, 6655 KHz, 8951 KHz, 10048 KHz, 11330 KHz, 13273 KHz, and 17904 KHz.

b. Guard Station. The oceanic radio station guarding for flight operations is normally the station associated with the ATC center responsible for the FIR. At the FIR boundary, the responsibility for the guard normally changes to the station associated with the new FIR. The flight must ensure that it establishes communication with each successive guard facility. Each oceanic radio station normally listens continuously on all assigned frequencies. If en route HF communications fail, every effort should be made by the flightcrew to relay progress reports through other aircraft. The VHF frequency 128.95 megahertz (MHz) is for exclusive use as an air-to-air communication channel. In emergencies, however, initial contact for such relays may be established on 121.5 MHz. In normal HF propagation conditions, appropriate overdue action procedures are taken by ATC in the absence of position reports or relays. In all cases of communication failure, the pilot should follow the oceanic clearance last received and acknowledged.

c. Air-to-Ground Very High Frequency (VHF) Communication. Oceanic radio stations normally have VHF capability within 200 NM of their geographic location. The frequency is listed in the appropriate publications. This frequency may be used prior to departure from the adjacent international airport to establish communication with the radio station, or for aircraft operating within range to relay progress reports or other messages to their company's operations. All international flights departing from Anchorage or Fairbanks, Alaska, should relay their departure time to the FAA Flight Service Station (FSS) on VHF for use in transmitting departure messages.

d. Air-to-Air VHF Communication. Frequency 128.95 MHz has been designated for use in air-to-air communications between aircraft operating in the Pacific area out of range of VHF ground stations to exchange operational information and facilitate resolution of operational problems.

e. Time and Position Reports. When operating on a fixed route with designated reporting points, aircraft should report over such points. Unless otherwise required by ATC, position reports for flights on routes not defined by designated reporting points should be made at the significant points listed in the flight plan. By requiring aircraft to report at intermediate points, ATC is guided by the requirement for positional information at ICAO established intervals and by the need to accommodate varying types of aircraft, traffic load, and weather conditions. When reporting to oceanic radio stations, the prefix "position" should be used on initial contact or prior to the text of the message. Keep in mind that the operator is typing the report into a teletype or computer terminal; it is imperative that the person transmitting the report speak slowly and distinctly so that the message can be correctly copied on the first attempt. To minimize radio frequency congestion, routine weather information and fuel remaining information should not be included in position reports made directly to Anchorage ARTCC. Position reports must include information on the present position, estimated next position, and ensuing position(s) in the sequence indicated below:

(1) Present position

(a) The word "position"

(b) Aircraft identification

(c) Reporting point name or, if not named:

(i) for east-west flights, latitude in degrees and minutes, and longitude in degrees only (in Tokyo FIR, degrees and minutes)

(ii) for north-south flights, latitude in degrees only (in Tokyo FIR, degrees and minutes) and longitude in degrees only (in Tokyo FIR, degrees and minutes)

(d) time over reporting point in four digits UTC

(e) altitude - FL at which the aircraft is currently operating, plus the assigned altitude if the aircraft is climbing or descending to an assigned altitude

(2) Estimated next position information shall include

(a) name of the next required position information point or, if not named, as in (1)(c) above; and

(b) estimated time over next position. If the estimated time is in error by more than 5 minutes (3 minutes in Tokyo FIR), a revised estimate shall be forwarded to Tokyo or Anchorage FIR, as appropriate, as soon as possible.

(3) Ensuing position information shall include the name of the next successive reporting point, whether compulsory or not. If the point is not named, use the procedure in (1)(c) above.

f. Special Reporting Procedures. All aircraft operating on ATS routes R220, R580, R591, and G344 must cross-check their position over reporting points abeam Shemya VORTAC (109.0 MHz, DME-27, identification SYA). In addition to normal reporting procedures, pilots shall provide the cross-check in terms of the DME distance when crossing the specified radial. The radial/DME distances are as follows:

- for NEEVA on R220, SYA 328R/135 DME
- for ONADE on R580, SYA 328R/068 DME
- for AMMOE on R591, SYA 148R/050 DME
- for CHIPT on G344, SYA 148R/100 DME

A July 1985 memorandum of understanding between the United States, USSR (currently Russia), and Japan provides for direct voice communication between Anchorage ARTCC, Tokyo ACC, and Khabarovsk ACC to allow coordination between these facilities in assisting civil aircraft in certain emergency situations. These situations are mechanical problems requiring immediate landing, unlawful seizure of an aircraft, loss of communication, unidentified aircraft in USSR (Russia) FIR, and possible entry of aircraft into USSR (Russia) FIR. This communication link is checked daily at 0000 UTC.

g. Transponder Codes. When operating west of 164E, transponders should be set to Mode A Code 2000. When east of 164E, a discrete code may be assigned. This code should be maintained unless otherwise advised by ATC. If no discrete code is assigned, transponders should be set to Code 2000.

5. MACH NUMBER TECHNIQUE.

a. Background. The term "mach number technique" is used to describe the technique of clearing turbojet aircraft operating along the same route to maintain specified mach numbers in order to maintain adequate longitudinal separation between successive aircraft at, climbing to, or descending to the same altitude. The principal objective of the use of this technique is to improve use of the airspace on long routes where ATC has no means other than position reports to ensure the longitudinal separation of aircraft is not reduced below the established minimum. Experience has demonstrated that two or more turbojet aircraft on the same route and FL are more likely to maintain a constant time interval when this technique is used. This is because the aircraft are normally subject to the same wind and air temperature, and minor variations in speed tend to be neutralized over long periods of flight.

b. Application Procedures. Information on the planned mach number must be included in the flight plan for turbojet aircraft operating in oceanic airspace. For all flight plans, the true mach number must be included in Item 15 of the ICAO flight plan. The true airspeed (TAS) in knots equivalent to the planned mach number shall be specified in the remarks section of Item 18 on the same form, along with the abbreviation "TAS" and the four-figure group. When the mach number technique is applied, the normal requirement for ATC to calculate estimated times for the aircraft to pass significant points still applies. This is necessary to ensure longitudinal separation and coordination between ATC units. Intervention by ATC should not be necessary unless position reports indicate that longitudinal separation may be deteriorating to unacceptable levels. In applying this technique, it is imperative that pilots adhere strictly to their assigned cruise mach number at all times, including during climbs and descents, unless a specific reclearance is obtained from

ATC. If an immediate temporary change in the mach number is essential before a revised clearance can be obtained, ATC must be notified as soon as possible that a change has been made.

6. IN-FLIGHT CONTINGENCIES.

a. General. Not all contingencies can be covered in this Advisory Circular (AC), but the following procedures provide for cases such as inability to maintain FL due to weather, aircraft performance, and pressurization failure. They are useful when rapid descent, turn back, or both are required. The pilot's judgment determines the sequence of actions taken.

b. Basic Procedures. If an aircraft experiences navigational difficulties, it is essential that the pilot inform ATC as soon as possible so that the appropriate action can be taken to prevent conflict with other aircraft. If an aircraft is unable to continue flight according to ATC clearance, a revised clearance shall be obtained whenever possible before any action is taken. If prior clearance cannot be obtained, ATC clearance shall be obtained at the earliest possible time. In the interim, the aircraft shall broadcast its position and intentions, including the ATS route designator, on 121.5 MHz at suitable intervals until ATC clearance is received. In such circumstances, communication may also be accomplished on VHF with certain stations, such as ADAK approach on 134.1 MHz; Shemya Tower on 126.2 MHz; Anchorage Center on 118.5 MHz (Cold Bay); on 124.4 MHz at Dutch Harbor; on 127.8 MHz at St. Paul Island; and on 128.2 MHz at Shemya.

If unable to comply with these procedures, the aircraft should leave its assigned route by turning 90 degrees to the right or left whenever possible. The direction of the turn should be determined by the position of the aircraft relative to the route system. Aircraft operating on ATS Route R220 under these circumstances should, if possible, avoid turning northward to leave the route because of the route's proximity to the boundary between Anchorage/Tokyo and the USSR (Russia) FIR. An aircraft that is able to maintain its assigned level should climb or descend 500 feet while acquiring and maintaining, in either direction, a track laterally separated from its assigned route by 20 NM. For subsequent level flight, a level should be selected that differs by 500 feet from those normally used.

CHAPTER 5. SOUTHERN PACIFIC OCEANIC OPERATIONS

1. CENTRAL EAST PACIFIC (CEPAC) COMPOSITE AIRSPACE. CEPAC composite airspace is an organized route system, at or above flight levels (FL) 290 between the west coast of the continental United States and Hawaii, within the Honolulu and Oakland Control Areas (CTA) Flight Information Region (FIR). The organized route system between Hawaii and Los Angeles or San Francisco is comprised of six air traffic service (ATS) routes from FL 290 to FL 410. The same rules used for the North Pacific (NOPAC) routes apply to these routes, including mach number technique and contingencies.

2. CENTRAL PACIFIC AREA (CENPAC). Oakland Oceanic CTA has designated the airspace south of G344 (southernmost NOPAC route) and north of Hawaii as the CENPAC area. Two air traffic routes have been constructed in this area: A227 and R339. These are standard ATS routes with no special separation requirements, and there are no special rules to file a flight plan or to fly on these routes. Just south of R339, a free flow boundary has been established. When operating north of this boundary, flight must be conducted on one of the five NOPAC routes or on A227 or R339. Random traffic is only authorized south of the free flow boundary.

3. TOKYO-HONOLULU FLEXIBLE TRACK SYSTEM. A flexible track system (FTS) consisting of two flexible track routes (FTR) is permanently established between Tokyo and Honolulu to achieve more efficient use of the airspace for traffic operating at FL 290 or above. The routes are effective daily between 1200 coordinated universal time (UTC) and 1700 UTC within the Tokyo fix, and between 1300 UTC and 1900 UTC within the Oakland fix. The routes are published daily in Class 1 Notices to Airmen (NOTAM) and are designated "North FTS" and "South FTS." The FTS must be filed on the International Civil Aviation Organization (ICAO) flight plan by coordinates.

4. COMMUNICATIONS AND POSITION REPORTING.

a. Communications. Most CEPAC and CENPAC area communications are conducted on high frequency (HF), predominantly by single side band (SSB). Pilots communicate with control centers via oceanic radio stations. Aircraft reports, messages, and requests are relayed by the station to the appropriate air traffic control center (ATCC) by interphone, computer display, or teletype message. The relay function, coupled with the need for intercenter coordination, may cause delays in the handling of routine aircraft requests. There are priority message handling procedures for processing urgent messages that reduce any time lag; however, the crew should take possible delays into consideration when requesting step climbs, reroutes, or other routine requests requiring air traffic control (ATC) action. Delays can be reduced by advance planning of such requests.

b. Frequency monitoring. Aircraft should establish communications with the appropriate oceanic radio station upon entering a specific FIR. The station advises the aircraft of the primary and secondary HF frequencies in use. If possible, the flightcrew should monitor both of these frequencies. If only one frequency can be monitored, the primary should be guarded with the secondary being the first one checked in the event of lost communications on the primary frequency. If the selective calling (selcal) unit is working at the time of the initial contact, the crew should maintain a selcal watch on the appropriate frequencies. If the selcal unit is inoperative, or if the radio station has a malfunctioning selcal transmitter, the crew should maintain a listening watch. The oceanic station guarding for flight operations is normally the station associated with the ATCC responsible for the FIR (i.e., Honolulu Aeronautical Radio, Incorporated (ARINC) for the Anchorage FIR and Tokyo Radio for the Tokyo FIR). At the FIR boundary the responsibility for the guard is changed, under normal signal conditions, to the station associated with each new FIR. The flightcrew must ensure that it has established communications with the new guard facility. Normally, each oceanic radio station continuously listens on all assigned frequencies. If en route HF communications fail, every effort should be made by the flightcrew to relay progress reports through other aircraft. The very high frequency

(VHF) frequency 128.95 megahertz (MHz) is for exclusive use as an air-to-air communications channel. In emergencies, however, initial contact for such relays may be established on 121.5 MHz (the frequency guarded by all aircraft operating in the oceanic airspace) and transferred as necessary to 128.95 MHz. In normal HF propagation conditions, appropriate overdue action procedures are taken by ATC in the absence of position reports or relays. In all cases of communications failure, the pilot should follow the oceanic clearance last received and not revert to the original flight plan.

5. MACH NUMBER TECHNIQUE. Mach number technique for the South Pacific is identical to that used in NOPAC (see paragraph 5 in Chapter 4).

6. IN-FLIGHT CONTINGENCIES.

a. General. The procedures for in-flight contingencies are often aircraft specific, and therefore cannot be covered in detail here for every aircraft. However, the procedures listed provide for such cases as inability to maintain assigned FL due to weather, aircraft performance, and pressurization failure. These procedures are primarily applicable when rapid descent, turning back, or both are necessary. The pilot's judgment determines the sequence of actions taken while considering the specific circumstances.

b. Basic Procedures. If an aircraft experiences navigational difficulties, it is essential that the pilot inform ATC as soon as the condition is apparent so that appropriate action can be taken to prevent conflicts with other aircraft. If any aircraft is unable to continue flight in accordance with its ATC clearance, a revised clearance shall, whenever possible, be obtained prior to initiating any action, using the radio telephone distress or urgent signals, as appropriate. If prior clearance cannot be obtained, an ATC clearance shall be obtained at the earliest possible time; in the meantime, the aircraft shall broadcast its position (including the ATS route designator) and intentions on 121.5 MHz at suitable intervals until ATC clearance is received. In such circumstances, communications with certain VHF stations may be practical. Frequencies should be verified before using. A list of these stations follows:

Adak approach - 134.1 MHz	Anchorage Center - 127.4 MHz (Dutch Harbor)
Shemya tower - 126.2 MHz	Anchorage Center - 127.8 MHz (St. Paul Island)
Anchorage Center - 128.5 MHz (Cold Bay)	Anchorage Center - 128.2 MHz (Shemya)

If unable to comply with these provisions, the aircraft should leave its assigned route by turning 90 degrees to the right or left whenever possible. The direction of the turn should be determined by the position of the aircraft within the route system. The turn should be made in a direction that will keep the aircraft within the system and prevent any possible chance of a conflict with other traffic. For instance, aircraft on NOPAC routes should always turn south due to the proximity of these routes to the Russian FIR's. Aircraft on the northern route of the CEPAC route structure should turn south; aircraft on the southern route of the CEPAC route structure should turn north. An aircraft able to maintain its assigned level should, nevertheless, climb or descend 500 feet while acquiring and maintaining, in either direction, a track laterally separated by 25 nautical miles from its assigned route or track.

CHAPTER 6. CARIBBEAN OPERATIONS EXCLUSIVE OF THE GULF OF MEXICO

1. GENERAL INFORMATION.

a. International Flight Information Manual (IFIM). The following information is provided to inform crews of problem areas that may be encountered when traveling in the Caribbean, Central America, and South America. The IFIM contains specific information on an individual country's requirements for the following:

- Personal entry requirements.
- Embassy information.
- Aircraft entry requirements.
- Corporate aircraft restraints.
- Special notices.
- Aeronautical information sources.
- International Notices to Airmen (NOTAM) office.
- Airports of entry.

Detailed information regarding flights into Mexico is contained in the "Mexico Flight Manual," published by the Texas Aeronautic Commission, P.O. Box 12607, Capitol Station, Austin, Texas 78711.

b. Disease Control. Central and South American countries periodically experience epidemics of communicable diseases. Pilots and crews departing for destinations in the Caribbean, Central America, and South America should contact the U.S. Department of State in Washington, DC both well ahead of the proposed flight and just prior to the proposed flight. The initial contact should be made to determine if immunization is required and to determine the time period required for the immunizations to become effective. Some countries will actually isolate a crew and/or passengers if a particular immunization has not run the course of its incubation period. The final contact to the State Department is made to determine the latest health warnings in effect at the destination and/or possible intermediate stopping points. Under the International Health Regulations adopted by the World Health Organization, a country may require International Certificates of Vaccination against yellow fever and cholera from international travelers. No vaccinations are required to return to the United States from any country.

c. Passports. Those countries that do not require a passport to frequently enter or depart, require both crews and passengers to have documentary evidence of identity and U.S. citizenship. Although a passport is the best form of identification, a birth certificate, Certificate of Naturalization, or Certificate of Citizenship may suffice as evidence of citizenship. Refer to Chapter 2, Section 4 of this advisory circular (AC) for additional information on passports and entry requirements.

d. Altimeter Settings. Pilots and crews should be especially aware of the altimeter setting requirements of many of the Caribbean Islands. Various islands have different altimeter setting requirements. For example, Grand Turk requires en route flight level (QNE) at flight level (FL) 60 or above, and Punta Caucedo in the Dominican Republic requires QNE above FL 40. (See Chapter 2 of this AC for definitions of QNE, field elevation (QNH), and airport altitude (QFE).)

2. BAHAMAS.

a. Aircraft Entry Requirements. Private aircraft overflying or landing in the Bahamas for noncommercial purposes need not obtain prior permission. However, prior notification to the destination airport is required, and a flight plan must be on file. Permission must be obtained from the Ministry of Transport for overflight and landing clearances for nonscheduled commercial aircraft. In addition to having a flight plan on file, nonscheduled commercial aircraft landing for commercial purposes must obtain permission from the Secretary, Air Transport Licensing Authority, P.O. Box N975, Nassau, New Providence, Bahamas, prior to departure.

b. Special Notices.

(1) Flights made between sunset and sunrise must be conducted under instrument flight rules (IFR). With the exception of Freeport International and Nassau International Airports, no aircraft will be permitted to land or take off at any location in the Bahamas between sunset and sunrise without prior approval from the Director of Civil Aviation.

(2) New Providence - Nassau: Amphibious aircraft on international flights landing at the Nassau Marine Base must first land at Nassau International Airport for customs and immigration clearance.

(3) Before turning onto final approach and taxiing out for takeoff, it is recommended that pilots announce their identification, location, and intention on 122.8 megahertz (MHz) at uncontrolled airports. Arriving aircraft should fly over the airstrip at 1,000 feet above ground level to observe other traffic and fly a left-hand pattern. Extreme caution should be exercised when flying an approach or taking off from any of the outer islands. These fields are uncontrolled, but the attractiveness of the Caribbean makes them very popular destinations for both commercial operators and pleasure pilots. A wide range in crew island-flying ability levels often exists, and aircraft using these uncontrolled fields have significant differences in performance capabilities.

3. CUBA.

a. Personal Entry Requirements. The accuracy and currency of the following information is uncertain because of the difficulty in obtaining information about this country. All aircraft arriving from or departing for Cuba must land at or depart from Miami International Airport. A passport and a visa are required.

b. Aircraft Entry Requirements. All private and nonscheduled commercial aircraft overflying or landing for commercial or noncommercial purposes must obtain prior approval from the Ministerio Del Transporte Area Aeronautica, Calle 23-No. 64 Vedado, Plaza de la Revolucion, Cuidad de La Habana 4, Cuba at least 48 hours prior to overflying, and at least 10 days prior if landing. All requests must include provisions for prepaid reply. All requests must include the following information:

- Name, nationality and address of the aircraft operator.
- Aircraft type and registration marks.
- Name of pilot-in-command (PIC).
- Place of origin and destination.
- Air corridor and routes to be used under the flight plan.
- Date of the flight.
- Purpose of the flight.
- Number of passengers and type and amount of cargo.
- Statements of third party insurance liability coverage.
- Radio frequencies available.

All flights into Cuban airspace, including those in the established air corridors of Maya, Giron, and Nuevas, must be able to establish and maintain communications with Havana flight information region (FIR)/control area (CTA) 10 minutes prior to airspace entry. All flights must have a flight plan on file with Havana FIR/CTA at least 1 hour prior to airspace entry. In addition, any aircraft overflying or landing in Cuba must carry the following documents on board:

- Registration certificate.
- Certificate of airworthiness.
- Licenses (certificates) for all crewmembers.
- Aircraft logbooks.
- The onboard radio station licenses.
- A list of passengers' names showing places of embarkation and destination.
- A manifest and detailed declaration of all cargo carried.

c. Special Notices. A NOTAM dated April 1, 1993, contained the following warning regarding Cuban airspace: "The Federal Aviation Administration has been informed that an official Cuban government publication has issued a warning that Cuban Armed Forces will shoot down any aircraft that penetrates Cuban airspace illegally and refuses to obey an order to land for inspection. All pilots should take note; use extreme caution in the area of Cuban airspace; adhere strictly to Cuban requirements for overflight of their territory." Any aircraft that flies over Cuban national territory or jurisdictional waters may be intercepted and required to land if any of the following occur:

- Flying over national territory and jurisdictional waters without proper authorization.
- Flying without proper authorization outside of national routes or established international corridors.
- Executing inappropriate maneuvers.
- Not following any of the instructions from air traffic control (ATC).

d. Legal Considerations. Aircraft that have been ordered to land, or have landed without proper authorization, will be subject to whatever penalties the Cuban authorities may prescribe, without recourse. The pilot and/or aircraft owner will be held responsible for any damage, injuries, or resulting expense. No aircraft may make an overflight carrying photographic equipment, arms, ammunition, explosives, or other articles and substances the Cuban aeronautical authority may specify. Overflights shall not be authorized if the operation constitutes a danger to air navigation or if, in the judgment of the Cuban aeronautical authority, the operator does not offer adequate guaranties to cover any liability incurred because of the overflight. These liabilities include damage and loss caused to subjacent persons or property, and payment for any services rendered or obligations that may arise in connection with the overflight. The use of Cuban radio for flight information, ATC, or other purposes is considered a service, and operators should expect to be billed for its use. Any person or corporation, partnership, organization, or association subject to U.S. jurisdiction and considering the operation of aircraft into Cuba must review current Department of Commerce and Department of State regulations relating to trade and other transactions involving Cuba. Within 1 hour of departure, the PIC must file an IFR flight plan and a written statement with the Immigration and Naturalization Service office at the departure airport. This statement must contain all of the information in the flight plan, the name of each occupant of the aircraft, the number of occupants in the aircraft (including the flightcrew), and a description of any cargo. The U.S. Naval airfield/facilities located at Guantanamo Bay, Cuba are closed to all civilian air traffic except for valid emergencies. All emergency landings will be thoroughly investigated by U.S. authorities to determine their validity and the nature of their business.

4. SOUTH FLORIDA DEPARTURES.

a. Special Airspace Considerations. South Florida has a complex airspace environment. Class C airspace exists at Sarasota, Fort Meyers, Fort Lauderdale, and West Palm Beach. Class B airspace exists at Tampa, Orlando, and Miami with their associated 30 nautical miles (NM) Mode C veils. All pilots should be aware of these areas and be familiar with all associated regulations pertaining to equipment and communication requirements. The new airspace classification went into effect in September 1993. Therefore, it is imperative that pilots have current charts in the cockpit and that the flightcrew has a comprehensive knowledge of the new classifications.

b. National Parks, Wildlife Refuges, and Bird Activity. South Florida has a number of national parks and wildlife refuges. These areas are home to large numbers of animals and birds, some of which are very sensitive to aircraft noise. Everglades National Park in particular is very aggressive about reporting low-flying aircraft to the FAA. Because of the large expanses of seacoast and the presence of large numbers of migratory birds during certain seasons, the possibility of bird strikes is a very real hazard in south Florida. Pilots should exercise added vigilance at low altitudes and be especially aware of the guidance in the Airman's Information Manual (AIM), Chapter 7, Section 4, entitled "Bird Hazards and Flights Over National Refuges, Parks and Forests."

c. Special Use Airspace and Military Activity. The Miami Aviation International Flight Service Station (AIFSS) keeps information on file concerning the status of special use airspace and military training routes in the airspace within 100 NM of their flight plan area. This airspace covers an area south of the Tampa, Orlando, and Melbourne areas. Information on special use airspace is not distributed by a NOTAM, and military training routes are included in pilot briefings only at the pilot's request. For information on activity more than 100 NM from Miami's flight plan area, contact the appropriate facility while en route.

d. Key West Naval Air Station. There is a high volume of military, high-speed jet aircraft operating in the Key West International and Navy Key West Airports. It is recommended that all civil air traffic proceeding to the Key West area from the direction of Marathon, Florida contact Navy Key West Tower on frequency 126.2 MHz when approximately 10 miles east of the Navy Key West Airport (at approximately Sugar Loaf Key - N24°39' W081°35') for traffic information and/or clearance through or around the Navy Key West Airport traffic area. Radar service is available through Navy Key West approach control on frequency 119.25 MHz. Visual flight rules (VFR) flights departing Key West International Airport should advise the tower of the direction of their flight.

e. Restricted Area R-2916. Of special safety interest in the Lower Keys, Restricted Area 2916 is an area of 4 statute miles in diameter, protected up to 14,000 feet mean sea level. This area contains a tethered aerostat balloon flown at various altitudes and times. All VFR pilots flying south to or across the Lower Keys should treat the restricted area as being active at all times and avoid the area. R-2916 is located 17.5 NM northeast of the Key West very high frequency (VHF) omnidirectional radio range (VOR) (113.5 EYW) on the 066 degree radial. Authorization to enter this area is granted by Miami Air Route Traffic Control Center (ARTCC) on 132.2 MHz.

CHAPTER 7. GULF OF MEXICO OPERATIONS

1. CHARACTERISTICS OF THE AIRSPACE.

a. General. The airspace above and surrounding the Gulf of Mexico is complex and includes heavy concentrations of multi-altitute military operations, high altitude air carrier operations, and low altitude helicopter activity. There are numerous alert, warning, noise-sensitive, and restricted areas; control zones; heavy concentrations of student pilot activity; and areas of communication and navigation unreliability. As the volume of air traffic in this area has increased, it has become more common for flights to deviate from track, fail to make position reports, or report an incorrect position. Separation of air traffic is a matter of increasing concern in this airspace because of this increased activity. Any operation that is conducted in international airspace on an instrument flight rules (IFR) flight plan, a visual flight rules (VFR) controlled flight plan, or at night and that continues beyond the published range of normal airways navigation facilities (nondirectional radio beacon (NDB), very high frequency (VHF) omnidirectional radio range (VOR)/distance measuring equipment (DME)) is considered to be a long-range navigation operation. Long-range navigation in a control area (CTA) requires that the aircraft be navigated to the degree of accuracy required for the control of air traffic; that is, the aircraft should remain within one-half of the lateral separation standard from the centerline of the assigned track. The aircraft should also remain within the established longitudinal and vertical separation standards for the area of operation. These separation standards can be found in the International Civil Aviation Organization (ICAO) Regional Supplementary Procedures Document 7030/2. For flights conducted within international airspace under U.S. jurisdiction, Federal Aviation Administration (FAA) Order 7110.83, "Oceanic Air Traffic Control Handbook" provides a simplified version of these separation standards. Federal Aviation Regulations (FAR) 91.703(a) requires that civil aircraft must comply with ICAO Annex 2 when operating over the high seas. Annex 2 requires that "aircraft shall be equipped with suitable instruments and with navigation equipment appropriate to the route being flown." In addition, Annex 6, Part II stipulates that an airplane operated in international airspace be provided with navigation equipment that will enable it to proceed in accordance with the flight plan and the requirements of the air traffic services. Annex 2 further requires that an aircraft shall adhere to the "current flight plan unless a request for change has been made and clearance received from the appropriate air traffic control (ATC) facility."

b. Control of Air Traffic. ATC of the airspace over the Gulf of Mexico is assigned to the Houston Air Route Traffic Control Center (ARTCC). This center controls airspace within and outside of the U.S. Air Defense Identification Zone (ADIZ). The Houston CTA/Flight Information Region (FIR) includes the airspace in the northern part of the Gulf of Mexico. This control extends southward from Houston Center's coastal CTA to the middle of the Gulf in the vicinity of longitude N24°30'. The Houston CTA/FIR borders Houston's coastal control in the west and north, and meets Miami's oceanic CTA/FIR at latitude W86 in the east. The southern border of the Houston CTA/FIR is under the control of several Mexican FIR/upper control areas (UTA) and is controlled by Havana CTA in the southeast. Flight operations in this area must be conducted in accordance with the applicable FAR and ICAO Annex 2, "Rules of the Air." The navigation and communication equipment required for operations over the high seas must be installed and fully operational for flight in this airspace.

c. Flight Plans. Unless otherwise authorized by ATC, no aircraft may be operated in oceanic airspace unless a flight plan has been filed. VFR operations in oceanic airspace are permitted only between sunrise and sunset at or below flight level (FL) 180. Although VFR flights are permitted in offshore airspace (the airspace between the U.S. 12-mile limit and the oceanic control area (OCA)/FIR boundary), instrument meteorological conditions (IMC) are commonly encountered. It is recommended that pilots hold an instrument rating, the aircraft be equipped for IFR flight, and that an IFR flight plan be filed.

d. Alert Areas. Alert areas are areas wherein a large volume of pilot training flights or unusual aeronautical activity is contained. All activity within alert areas must be conducted according to the FAR, without waiver, and no activity that may be hazardous to other aircraft may be conducted. All aircraft within an alert area, both participating and nonparticipating, are equally responsible for collision avoidance.

e. Controlled Firing Areas. Controlled firing areas contain activities such as the firing of missiles and rockets, ordnance disposal, and static testing of large rocket motors. The users of these areas are responsible for immediate suspension of activities in the event that the activity might endanger nonparticipating aircraft. The controlled firing area locations in the Gulf of Mexico are published in Notices to Airmen (NOTAM).

f. Key West International Airport. FAR Part 121 operations that land or depart from Key West International Airport must meet the special airport requirements of FAR 121.445.

g. Noise-Sensitive Areas. Noise-sensitive areas include outdoor assemblies of persons, churches, hospitals, schools, nursing homes, designated residential areas, and national park areas. As national park areas, wildlife refuges are considered noise-sensitive areas. Numerous wildlife refuges are located along the U.S. coastline surrounding the Gulf of Mexico, and many of these refuges have large bird populations. The heaviest concentrations of these refuges are along the Texas and Florida coasts. VFR flights over noise-sensitive areas should be no lower than 2,000 feet above the surface, weather permitting, even if flight at a lower altitude is otherwise permitted under FAR 91.119. The surface is defined as the highest terrain within 2,000 feet laterally of the route of flight, or the uppermost rim of a canyon or valley.

h. Warning Areas. Warning areas are established in international airspace and contain operations hazardous to nonparticipating aircraft. IFR clearances through this airspace can be issued when hazardous operations are not taking place. Because there is no provision in international agreements for prohibiting flights in international airspace, there is no restriction on flights in these areas. However, pilots should take note of the location of all warning areas along a planned route.

i. Restricted Areas. Restricted areas are designated under FAR Part 73 to contain activities considered hazardous to nonparticipating aircraft. Aircraft may not operate within 3 nautical miles (NM) of a restricted area unless authorized under the provisions of FAR 73.13. There are numerous restricted areas near and along the Gulf of Mexico coastline. Pilots should be aware of these areas and plan flights accordingly.

2. NAVIGATION AND COMMUNICATIONS IN THE GULF OF MEXICO.

a. Background. ICAO Annex 6, Part II contains standards and recommended practices adopted as the minimum standards for all airplanes engaged in general aviation international air navigation. It requires those aircraft operated in accordance with IFR, at night, or on a VFR controlled flights (such as in CTA/FIR oceanic airspace) to have installed and approved radio communications equipment capable of conducting two-way communication at any time with the appropriate aeronautical stations on the prescribed frequencies.

b. High Frequency (HF) and VHF Communications. Due to the inherent "line of sight" limitations of VHF radio equipment used for international oceanic airspace communications, aircraft operating on an IFR or controlled VFR flight plan beyond VHF communications capability are required to maintain a continuous listening watch and communications capability on the assigned HF frequencies. Although these frequencies will be assigned by ATC, actual communication will be with general purpose communication facilities such as an international flight service station (FSS) or Aeronautical Radio Inc. (ARINC). These facilities will be responsible for the relay of position reports and other information between the aircraft and ATC. Except in an emergency, the use of relay on VHF through aircraft operating at higher altitudes is not an acceptable method of communication with ATC.

c. Communication and Position Reporting. The following describes an area in the Houston CTA/FIR where direct air traffic communication is not available:

N27°28′ W086°00′ to N27°30′ W087°42′ to
N25°50′ W088°15′ to N25°37′ W091°55′ to
N24°40′ W093°19′ to N24°28′ W088°01′ to
N24°00′ W086°00′ to beginning point.

Pilots planning flights through this area should be aware of the communications and position reporting requirements. HF communications are available for all oceanic flights, and limited VHF coverage is also available on 130.7 megahertz (MHz). The communication requirements for IFR flights within the Houston OCA are as follows:

(1) The aircraft must have functioning two-way radio communications equipment capable of communicating with at least one ground station from any point on the route.

(2) The crew must maintain a continuous listening watch on the appropriate frequency.

(3) All mandatory position reports must be made.

d. Position Reports. When flying an oceanic route in the Gulf of Mexico, position reports must be made over all designated reporting points. A position report must also be made upon crossing the FIR boundary. Unless otherwise required, reporting points should be located at intervals of 5 or 10 degrees latitude (if flying north/south) or longitude (if flying east/west) either north or south of the equator or east or west of the 180 degree meridian. Aircraft transversing 10 degrees of latitude or longitude in 1 hour, 20 minutes should normally report at 10 degree intervals. Slower aircraft should report at 5 degree intervals. In the absence of designated reporting points, position reports shall be made as instructed by ATC. Position reports are vital to air traffic safety and control. Inability to comply is a violation of the FAR and ICAO requirements.

e. Navigation Requirements. Class II navigation on routes in the Gulf of Mexico can be conducted using GPS, VOR/DME, and NDB supplemented by dead reckoning (DR). These routes are located offshore and are shown on en route charts. The areas are established by FAA Order 7110.2C, "Procedures for Handling Airspace Matters," and serve aircraft operations between U.S. territorial limits, OCA/FIR boundaries, and/or domestic flights operating in part over the high seas. These transition CTA's permit ATC to apply domestic procedures and separation minimums. Because independent radar surveillance is maintained within these CTA's, separation minimums are not as large as for other OCA's. As long as radar surveillance is maintained, operations may be conducted on Gulf routes using VOR/DME and NDB supplemented by DR. The radar surveillance provides an equivalent level of safety even though DR may be required for extended periods. Because of the proximity of these routes to shore-based facilities, the accuracy of DR can be enhanced by the use of shore-based navigational aids (navaids). The DR techniques and procedures must be approved as part of the air carrier operator's training program, and should include contingency training for weather avoidance and emergencies. Approval for use of a single long-range navigation system on these routes, as well as the navigation techniques discussed in this paragraph, are part of the operations specifications issued to air carrier operators.

f. Use of NDB for Navigation. The use of NDB as a primary source of navigation on long-range flights presents the operator with numerous limitations and restrictions inherent in low frequency radio equipment and the low frequency signals they receive. NDB navaids of the highest power (2,000 watts or greater) that are maintained and flight checked as suitable for navigation, are limited to a usable service and/or reception range of 75 NM from the facility at any altitude. Although the operator may be able to receive standard AM broadcast stations with NDB equipment, primary dependence on these facilities for navigation is a questionable operating practice. The following are some of the inherent problems associated with reception of these stations:

(1) Infrequent station identification.

(2) Foreign language station identification may be impossible without knowledge of the language.

(3) Transmitter sites are not always located with the studio facilities.

(4) Termination of service without notice.

(5) Weather or atmospheric disturbances may cause erratic and unreliable signal reception.

(6) Flight checks may not have been conducted to verify the suitability and reliability of the facility and signal for navigation.

(7) The "shoreline/mountain" effect may cause signal fluctuations.

(8) Standard broadcast stations are not dedicated for navigation purposes.

Considering these limitations, the operator should be able to navigate so as to maintain the course specified in the ATC clearance. The inadequacies of NDB as the sole source of navigation must be carefully evaluated, as an error of 10 degrees over 2,000 miles can result in a deviation of 350 miles.

3. INTERNATIONAL OPERATIONS.

*a. **Operations to Mexico.*** Pilots should be aware of the landing restrictions in effect at Mexico City Airport. A fee of 3.77 million pesos (approximately $ 1,240) will be imposed on aircraft that land or depart from this airport during peak hours (7:00 am - 10:00 am; 5:00 - 9:00 pm). If an aircraft lands during peak hours but departs during nonpeak hours, 75 percent of the fee will be imposed. Operators planning a flight to Mexico should check the NOTAM's for updated information. FAR Part 121 operations to Guadalajara, Mexico must meet FAR 121.445 special airport qualification requirements.

*b. **Operations to Cuba.*** FAR 121.445 requirements for special airport qualifications apply to FAR Part 121 operations landing or departing from Guantanamo Bay Naval Air Station. Operators should be aware that the Cuban government has issued a warning that Cuban Armed Forces will shoot down any aircraft that penetrates Cuban airspace without authorization and refuses to land for inspection.

4. MILITARY AND HELICOPTER OPERATIONS.

*a. **Military Operations Areas (MOA).*** Military operations represent approximately one third of the air traffic in the Gulf of Mexico. These operations include a high volume of nonhazardous training flights, which are contained within MOA's. MOA's and military training routes (MTR) are shown on VFR and sectional maps. However, MTR's are subject to change every 56 days. Because the charts are only issued every 6 months, pilots are strongly advised to contact the nearest FSS for current route dimensions and status.

*b. **Helicopter Operations.*** Pilots should be aware of the nature and extent of helicopter operations within the Gulf of Mexico. The density of helicopter traffic is primarily due to the presence of numerous oil rigs and drilling platforms in the Gulf. The majority of these flights are below 2,000 feet mean sea level at varying distances from the coastline. Additional information on helicopter operations is contained in Chapter 9 of this advisory circular (AC).

CHAPTER 8. LONG-RANGE NAVIGATION

1. GENERAL NAVIGATION CONCEPTS, FAA POLICIES, AND GUIDANCE.

a. General Concepts. In the early days of aviation, few aircraft operated within any given area at the same time. The most demanding navigational requirements were to avoid obstacles and arrive at the intended destination with enough fuel remaining to safely complete a landing. As aviation evolved, the volume of air traffic grew and a corresponding need to prevent collisions increased. Today, the most significant and demanding navigational requirement in aviation is the need to safely separate aircraft. There are several factors that must be understood concerning the separation of aircraft by air traffic control (ATC).

b. Separation of Air Traffic. In many situations, ATC does not have an independent means such as radar to separate air traffic, and must depend entirely on information relayed from an aircraft to determine its actual geographic position and altitude. A flightcrew's precision in navigating the aircraft is critical to ATC's ability to provide safe separation. Even when ATC has an independent means such as radar to verify the aircraft's position, precise navigation and position reports, when required, are still the primary means of providing safe separation. In most situations, ATC does not have the capability or the responsibility for navigating the aircraft. ATC relies on precise navigation by the flightcrew. Therefore, flight safety in all instrument flight rules (IFR) operations depends directly on the operator's ability to achieve and maintain certain levels of navigational performance. ATC radar is used to monitor navigational performance, detect navigational errors, and expedite traffic flow. Any aircraft operating in accordance with ATC instructions must navigate to the level of accuracy required to comply with ATC instructions. Aircraft must be navigated with sufficient precision to avoid airspace where prior ATC clearance or ATC instructions must be obtained. For example, an aircraft flying adjacent to minimum navigation performance specifications (MNPS) airspace must fly with a degree of precision that ensures that aircraft will not inadvertently enter MNPS airspace.

c. VFR Flight. The control of air traffic requires that a certain level of navigational performance be achieved by visual flight rules (VFR) flights to ensure safe separation of aircraft and to expedite the flow of air traffic. During cruising flight, the appropriate VFR flight altitude must be maintained to ensure the required vertical separation between VFR and IFR aircraft and to assist in collision prevention. VFR aircraft must be navigated with sufficient precision to avoid weather conditions that would prevent visual contact with (and avoidance of) other aircraft, and with sufficient precision to locate a suitable airport and land safely. VFR aircraft that require navigational assistance from ATC adversely affect ATC's ability to control air traffic and expedite its flow.

d. The Concept of an ATC Clearance. Issuance of an ATC clearance by a controller, and the acceptance of this clearance by a pilot, is a negotiation process that establishes conditions for the prevention of collision hazards (in-flight and terrain). When a controller issues an IFR clearance, a three-dimensional block of airspace is reserved for that aircraft along the defined route. The controller also agrees to issue clearances to all other controlled air traffic to ensure that all assigned flight routes will be safely separated. When a pilot accepts an ATC IFR clearance, that pilot is agreeing to continuously remain within the assigned three-dimensional block of airspace and to adhere to the flight rules for that operation. The pilot is obligated to comply with this agreement unless an emergency is declared or an amended clearance is received. Any deviation outside the assigned airspace creates a flight safety hazard. In such cases, the aircraft has failed to navigate to the degree of accuracy required for air traffic control and has failed to comply with Federal Aviation Regulations (FAR) and International Civil Aviation Organization (ICAO) requirements. In a nonradar environment, ATC has no independent knowledge of the aircraft's actual position or its relationship to other aircraft. Therefore, ATC's ability to detect a navigational error and resolve collision hazards is seriously degraded when a deviation from an agreed upon clearance occurs.

*e. **Concept of Navigation Performance.*** The concept of navigation performance involves the precision that must be maintained for both the assigned route and altitude by an aircraft operating within a particular area. Navigation performance is measured by the deviation (for any cause) from the exact centerline of the route and altitude specified in the ATC clearance. This includes errors due to degraded accuracy and reliability of the airborne and ground-based navigational equipment and the flightcrew's competence in using the equipment. Flightcrew competence involves both flight technical errors and navigational errors. Flight technical error is defined as the accuracy with which the pilot controls the aircraft as measured by success in causing the indicated aircraft position to match the desired position. Standards of navigational performance vary depending on traffic density and the complexity of the routes flown. Variation in traffic density is reflected in the different separation minimums applied by ATC in these two areas. For example, the minimum lateral distance permitted between coaltitude aircraft in Chicago Center's airspace is 8 nautical miles (NM) (3 NM when radar is used), while in North Atlantic (NAT) MNPS airspace it is 60 NM. The airspace assigned by ATC has lateral dimensions on both sides of the exact centerline of the route of flight specified in the ATC clearance equal to one-half of the lateral separation standard (minimum). For example, the overall level of lateral navigation performance necessary for flight safety must be within 4 NM of the airway centerline in Chicago Center's airspace, and within 30 NM in NAT MNPS airspace. FAR's 121.103 and 121.121 require that each aircraft must be navigated to the degree of accuracy required for air traffic control. FAR 91.123 requirements related to compliance with ATC clearances and instructions also reflect this fundamental concept. The concept of navigational performance is also inherent in the ICAO Standards and Recommended Practices (SARP). For example, Annex 2 states that the aircraft "shall adhere to its current flight plan" and "when on an established air traffic service (ATS) route, operate along the defined centerline of that route."

*f. **Degree of Accuracy Required.*** The fundamental concept for all IFR navigation standards, practices, and procedures is that all IFR aircraft must be navigated to the degree of accuracy required for control of air traffic. When a flight remains within the assigned three-dimensional block of airspace at all times, that aircraft is considered to be navigated to the degree of accuracy required for the control of air traffic. If an aircraft deviates outside its assigned block of airspace (except during a declared emergency), that aircraft has not been navigated to the required degree of accuracy. ATC separation minimums represent the minimum dimensions of a three-dimensional block of airspace that can be assigned by ATC to control flight. These separation minimums have been established for IFR operations in controlled airspace. These standards are usually established through international agreement and implemented through national regulations. These minimums are established for particular categories of navigational operation and specified areas. Examples include navigation on airways in the national airspace of ICAO member states and long-range navigation in oceanic or remote land areas. Separation minimums establish the minimum lateral, vertical, and longitudinal distances that can be used to safely separate aircraft operating within a specified area. Separation minimums also represent the minimum level of overall navigation performance which can be accommodated at any time without jeopardizing flight safety. Any aircraft deviating greater than one-half the separation minimums established for that operation has failed to meet the required level of navigational performance and to navigate to the degree of accuracy required for control of air traffic. For example, the vertical separation minimum for airplanes operating above flight level (FL) 290 in the United States is 2000 feet. Each aircraft's actual altitude must remain within + 1000 feet of the assigned altitude even when factors such as atmospheric pressure variations and instrument or pilot errors are considered. Where ATS's are provided by the United States, separation minimums are established by the FAR and ATC directives. Where ATS's are provided by contracting ICAO member states, separation minimums are established by those states' national regulations and in ICAO documents. Operations in uncontrolled airspace are not provided ATS, and separation minimums are not normally established for uncontrolled airspace. U.S. national airspace separation minimums can be found in FAA Order 7110.65, "Air Traffic Control." FAA Order 7110.83, "Oceanic Air Traffic Control," prescribes separation minimums in international oceanic airspace delegated to the United States by ICAO. ICAO Document 7030/3, "Regional Supplementary Procedures," prescribes separation minimums in international airspace.

g. FAR Part 91 Communication Equipment Requirements. FAR 91.511 states the equipment requirements for overwater flights operating more than 30 minutes flying time or 100 NM from the nearest shore. The PIC is required to maintain a continuous listening watch on the appropriate frequency when operating under IFR in controlled airspace.

h. FAR Part 121 Communication Equipment Requirements. Communication equipment requirements for Part 121 operations are contained in FAR's 121.347 and 121.349. Under FAR 121.351(a), extended overwater operations may not be conducted unless the communication requirements of FAR's 121.347 and 121.349 are met. FAR 121.99 communications facilities requirements may be waived for Part 121 operators for flights over certain oceanic areas with one high frequency (HF) radio inoperative if certain conditions and limitations are met.

i. FAR Part 135 Communication Equipment Requirements. The communication equipment required for turbojet airplanes with 10 or more passenger seats and multiengine commuter airplanes are contained in FAR 135.165(a). All other aircraft operated under FAR Part 135 must meet the requirements of FAR 135.165(b). Under FAR 135.165(b)(7), aircraft are required to have an additional communication transmitter for extended overwater operations.

j. Communication Equipment Requirements for Ferry Flights. FAR 91.511 contains the requirements for radio equipment for overwater operations for ferrying FAR Parts 121 or 135 aircraft under Part 91. Certain operable communications equipment must be carried on large and turbine powered multiengine aircraft flown overwater. If both HF and very high frequency (VHF) equipment are required under FAR 91.511, FAR 91.511(d) permits overwater operations with only one HF transmitter and one HF receiver provided that the aircraft is equipped with two independent VHF transmitters and receivers.

k. Concept of Operational Service Volume. The concept of operational service volume is critical to understanding and applying the principles of air navigation. Operational service volume is the volume of airspace surrounding an ICAO standard airways navigation facility that is available for operational use. Within that volume of airspace a signal of usable strength exists and that signal is not operationally limited by cochannel interference. Within this volume of airspace, a navigational aid (navaid) facility's signal-in-space conforms to flight inspection signal strength and course quality standards including frequency protection. ICAO standard navaids are VHF omnidirectional radio range (VOR), VOR/distance measuring equipment (DME), and nondirectional radio beacon (NDB). The national airspace systems of ICAO contracting member states are based on the operational service volume of these facilities. Navigational performance within the operational service volume and ATC separation minimums can be predicated on the use of these facilities. In contrast, the signal-in-space outside the operational service volume has not been shown to meet the flight inspection signal strength, course quality, and frequency protection standards. Therefore, navigational performance and ATC separation minimums cannot be predicated on the use of these facilities alone.

l. Categories of Navigational Operations. A thorough comprehension of the categories of navigational operations is essential to understanding air navigation concepts and requirements, and in evaluating an operator's ability to navigate to the required degree of accuracy. In the broad concept of air navigation, two major categories of navigational operations are identified in the ensuing paragraphs:

m. Class I Navigation. Class I navigation is defined as any en route flight operation conducted in controlled or uncontrolled airspace that is entirely within operational service volumes of ICAO standard navaids (VOR, VOR/DME, NDB). The operational service volume describes a three-dimensional volume of airspace within which any type of en route navigation is categorized as Class I navigation. Within this volume of airspace, IFR navigational performance must be at least as precise as IFR navigation is required to be using VOR, VOR/DME (or NDB in some countries). The definition of Class I navigation is not dependent upon the equipment installed in the aircraft. For example, an aircraft equipped and approved to use Loran-C in the United States as the sole means of en route navigation (no VOR, VOR/DME installed) is conducting Class I navigation when the flight is operating entirely within the operational service volume of federal

VOR's and VOR/DME's. In this example, the Loran-C's IFR navigational performance must be as precise as IFR navigation is required to be using ICAO standard navaids, if IFR operations are to be conducted. In another example, a VFR flight navigated by pilotage is conducting Class I navigation when operating entirely within the operational service volume. However, the VFR navigational performance in this example must be only as precise as VFR pilotage operations are required to be.

The lateral and vertical extent of the airspace where Class I navigation is conducted is determined solely by the operational service volumes of ICAO standard navaids. Class I navigation cannot be conducted outside of this airspace. Class I navigation also includes VFR or IFR navigation operations on the following:

- federal airways
- published IFR direct routes in the United States
- published IFR off-airway routes in the United States
- airways, advisory routes (ADR), direct routes, and off-airway routes published or approved by a foreign government provided that these routings are continuously within the operational service volume (or foreign equivalent) of ICAO standard navaids

Class I navigation requirements are directly related to separation minimums used by ATC. IFR separation minimums applied in the U.S. national airspace system and most other countries are based on the use of ICAO standard navaids. These separation minimums, however, can only be applied by ATC within areas where the navaid's signal-in-space meets flight inspection signal strength and course quality standards. An ICAO standard navaid's signal-in-space conforms to flight inspection signal strength and course quality standards (including frequency protection) within its designated operational service volume. Therefore, air navigation and the safe separation of aircraft within that service volume can be predicated on the use of these facilities.

Within areas where the safe separation of aircraft is based on the use of ICAO standard navaids, any IFR operation must be navigated with at least the same precision as that specified by the appropriate national separation minimums. Any operation or portion of an operation (VFR or IFR) in controlled or uncontrolled airspace, with any navigation system (VOR, VOR/DME, NDB, Loran-C, inertial navigation system (INS), Omega) or any navigational technique (dead reckoning (DR), pilotage), is Class I navigation for that portion of the route that is entirely within the operational service volume of ICAO standard en route navaids.

n. Class II Navigation. Class II navigation is any en route operation that is not categorized as Class I navigation and includes any operation or portion of an operation that takes place outside the operational service volumes of ICAO standard navaids. For example, an aircraft equipped with only VOR conducts Class II navigation when the flight operates in an area outside the operational service volumes of federal VOR's/DME's.

Class II navigation involves operations conducted in areas where the signals-in-space from ICAO standard navaids have not been shown to meet flight inspection signal strength, course quality, and frequency protection standards. Therefore, ATC cannot predicate aircraft separation on the use of these facilities alone and must apply larger separation criteria. When operating outside the operational service volume of ICAO standard navaids, signals from these stations cannot be relied upon as the sole means of conducting long-range operations to the degree of accuracy required for the control of air traffic or as the sole means of obstacle avoidance. Therefore, when operating outside the designated operational service volumes of ICAO standard navaids, operators must use long-range navigation systems (LRNS) (GPS, Loran-C, Omega, INS) or special navigational techniques (DR, pilotage, flight navigator, celestial) or both. These systems and/or techniques are necessary to navigate to the degree of accuracy required for the control of air traffic and to avoid obstacles.

The definition of Class II navigation is not dependent upon the equipment installed in the aircraft. All airspace outside the operational service volume of ICAO standard navaids is a three-dimensional volume of airspace within which any type of en route navigation is categorized as Class II navigation. For any type of navigation within this volume of airspace, the IFR navigational performance must be at least as precise as the navigational performance assumed during establishment of the ATC separation minimums for that volume of airspace. The navigational performance for VFR operations in a Class II navigation volume of airspace must be only as precise as VFR navigation operations are required to be.

In many cases when ATC lateral separation minimums are large (usually 90 NM or greater), and the Class II navigation portion of the flight is short (less than 1 hour), it is possible to meet required levels of navigational performance and conduct Class II navigation using ICAO standard navaids supplemented with special navigational techniques such as DR. For example, it is possible in turbojet airplanes (with proper procedures and training) to fly many routes between the southeastern United States, Caribbean Islands, and South America with VOR/DME and NDB equipment. In these situations, Class II navigation requirements can be met even though significant portions of these routes (less than 1 hour) are outside (beyond) the operational service volumes of ICAO standard navaids. In the domestic United States, it is not uncommon for low altitude VFR flights in aircraft such as helicopters to conduct Class II navigation while outside the operational service volumes of ICAO standard navaids when operating over routes of less than 100 NM in length. Obviously, Class II navigation includes transoceanic operations and operations in desolate/remote land areas such as the Arctic.

Class II navigation does not automatically require the use of long-range navigation systems. In many instances, Class II navigation can be conducted with conventional navaids if special navigational techniques are used to supplement these navaids. Any portion of an en route operation in controlled or uncontrolled airspace, with any navigation system or any navigation technique, is defined as Class II navigation for that portion of the route that is outside (beyond) the operational service volumes of ICAO standard en route navaids.

2. LONG-RANGE NAVIGATION PROCEDURES AND COLLISION AVOIDANCE.

a. Background. Recently an aircraft deviated approximately 60 miles from an assigned NAT track and came within a few feet of colliding with an aircraft assigned to an adjacent track. Following the near miss, the aircraft that had deviated from its track did not follow established contingency procedures for aircraft experiencing navigational uncertainty, thus creating the potential for further conflict with other aircraft as it returned to its assigned track. In this incident, as in the majority of incidents involving gross navigation errors (GNE), the navigation equipment DID NOT malfunction. The incident was caused by the crew's failure to operate the navigation equipment in a disciplined systematic manner during all phases of flight. The incident was further complicated by the crew's failure to comprehend the relationship between navigation performance, contingency procedure, and collision avoidance.

Although navigation errors are infrequent, human errors account for a majority of the errors attributed to aircraft equipped with automated systems. Most inadvertent navigation errors have occurred when the equipment was functioning normally, but the operating procedures prescribed were either inadequate or were not followed. Experience indicates that the increased accuracy and reliability of modern automatic navigation systems can induce a degree of complacency on the part of flightcrews, and may result in failure to routinely cross-check system performance. Under these circumstances, human errors may remain undetected for excessive periods. A common error associated with automated systems is incorrect programming of the oceanic waypoint latitudes by multiples of one degree (60 NM). In an organized track system (OTS), this can result in the flight maintaining a wrong track with high precision and thereby constituting a serious threat to other aircraft properly occupying that track and FL. Vigilance and diligence in properly applying established procedures are essential to safe oceanic navigation. Although operational procedures (checklists) may differ among navigation systems, many good practices and procedures are basic to all automated and semiautomated systems.

IFR long-range operations using pilot-operated electronic long-range navigation equipment shall use the practices and procedures recommended in this advisory circular (AC). Prior to issuing operations specifications authorizing operations requiring long-range navigation equipment, the FAA principal operations inspector (POI) should ensure that these practices and procedures are included and emphasized in the operator's training program, manuals, and check airman program. These basic practices and procedures should be used in conjunction with the more detailed flight planning guidelines in Chapter 2 of this AC. For operations currently authorized by operations specifications or a Letter of Authorization (LOA), the operator's navigation program should be reviewed to ensure that it follows the guidance contained in Chapter 3 of this AC. Any deviation from these requirements must be approved by an FAA navigation specialist through the Flight Standards National Field Office, AFS-500 at Dulles International Airport, Washington, DC 20041.

b. Weather. In addition to the normal review of weather information concerning terminals, crews should be alert for hazardous weather that may require a flight plan change or in-flight rerouting. It is important to obtain a copy of the wind flow chart (constant pressure chart or the equivalent) for the FL and route to be flown. This information may be valuable when evaluating wind forecasting errors, or if DR operations become necessary due to equipment failure. It is desirable to plot the flight route on the chart to increase its usefulness. Also, as the flight progresses, consideration should be given to plotting actual wind information on the chart as a means of evaluating the accuracy of the forecast.

c. Notices to Airmen (NOTAM). Besides checking NOTAM's for departure, destination and alternate airports, NOTAM's concerning navaids or special airspace restrictions along the planned route should be checked. Omega users should obtain NOTAM's concerning Omega station operational status to ensure that the required stations are in service. Further information concerning Omega is contained in Section 7 of this Chapter.

d. Waypoint Symbology. The navigation program should include a standard system for indicating waypoint status, as detailed below. The specific symbology recommended is noted in parenthesis. Variations in specific symbology may be necessary to accommodate the individual operator's program.

(1) Waypoint coordinates have been stored in the computer. (Enter the waypoint number next to the relevant waypoint coordinates.)

(2) Coordinates and zone distances have been independently cross-checked by a second crewmember. (Circle the waypoint number.)

(3) Coordinates and zone distances have been cross-checked during the approaching waypoint check. (Draw a diagonal line through the waypoint number.)

(4) Waypoint passage has occurred. (Draw a second diagonal line through the waypoint number.)

(5) Cross-checking during all phases of flight (flight planning, preflight, en route).

(6) Official (master) document.

(7) Plotting.

e. Plotting Procedures. Use of plotting procedures has had a significant impact on the reduction of GNE's. The use of this technique to plot the flight route on a plotting chart and to plot the computer position approximately 10 minutes after waypoint passage are strongly recommended on all flights when long-range navigation equipment is the sole means of navigation. Use of plotting procedures may be required for routes of shorter duration that transit airspace where special conditions exist, such as reduced lateral separation standards, high density traffic, or proximity to potentially hostile border areas. Plotting procedures should be required for all turbojet operations where the route segment between the operational service volume of ICAO standard navaids (VOR, VOR/DME, NDB) exceeds 725 NM, and for all turboprop operations where the route segment between the operational service volume of ICAO standard navaids exceeds 450 NM. The operational service volume is that volume of airspace surrounding a navaid which is available for operational use, within which a signal of usable strength exists, and where that signal is not operationally limited by cochannel interference. (See Section 1 of this Chapter for additional information on operational service volume.) The operational service volume for a specific navaid can be determined by contacting the Frequency Management Section within each regional Airway Facilities Division. Operational service volume includes the following:

(1) the officially designated standard service volume excluding any portion of the standard service volume that has been restricted

(2) the extended service volume

(3) within the United States (including offshore control areas (CTA)) by published instrument flight procedures (Victor or jet airways, standard instrument departures (SID), standard terminal arrivals (STAR), standard instrument approach procedures (SIAP), or instrument departure)

(4) outside the United States, any designated signal coverage or published instrument flight procedure equivalent to U.S. standards

f. Flight Planning. Many operators use a computerized navigation flight plan. Care should be taken to verify that all en route waypoints are correctly and legibly shown on the flight plan. It is good practice to select a waypoint loading sequence and number each waypoint accordingly. If more than one copy of the flight plan is to be used, one copy should be designated as the official copy. To eliminate possible confusion, ensure that all necessary information (i.e., routing changes, estimated time of arrival (ETA), waypoint loading sequence) is recorded on this flight plan, and this official copy is used for all reports to ATC. Additionally, if the flight is within the NAT OTS, obtain a copy of the current track message (ATC expects the flightcrew to have a copy) and be alert for conflict between the flight plan and the track message. Track messages are issued approximately every 12 hours and describe the NAT routes, gateways and FL's available for eastbound and westbound flights during the period indicated. While planning an overwater flight, pilots should review NOTAM's for any condition that may affect the operation and accuracy of long-range navigation systems (LRNS). This is especially critical for Omega and Loran-C systems, as discussed in those sections of this Chapter. The use of heading information for cross-checking must be approached with caution. In steering a given route segment with a navigation computer, the true heading required to maintain a Great Circle course will change. For example, the true heading to maintain the Great Circle course from 50N 30W to 50N 40W will be 274 degrees at 30W, 270 degrees at 35W, and 265 degrees at 40W. Differences in variation along the route will further change the magnetic heading required to maintain course. The flightcrew must have a thorough understanding of the flight plan heading information and DR technique in order to use this check with any degree of certainty.

g. Navigation Preflight (at aircraft). Navigation system software identification and modification status codes should be verified. Cross-check inputs to navigation computers. Each insertion should be carried out in its entirely by one crewmember and then recalled and verified by another. Cross- check computer flight plan zone distances with zone distance displayed in navigational computers. The cross-check of coordinates and zone distances must be performed on all computer systems individually when the remote loading feature is utilized. For INS, after the systems are placed in the navigation mode, the groundspeed should be checked while the aircraft is stationary. A reading of more than a few knots may indicate an unreliable system. INS procedures are covered in Section 6 of this Chapter.

(1) Cross-check computer flight plan (CFP) gate and waypoint coordinates and identifiers with source documents (airfield diagrams, en route charts, and NAT track messages, if applicable).

(2) Plot the flight route on a chart of appropriate scale. Operational experience has demonstrated that a scale of 1 inch to 120 NM provides the most benefit for plotting purposes.

(3) Compare routing information on ATC flight plans, computer flight plans, NAT track messages, plotting charts, and aircraft observations and reports (AIREP) forms.

(4) It is advisable not to copy waypoint coordinates from source documents (track message, en route charts, etc.) to the flight plan for subsequent insertion into the navigation computers. To avoid errors in transcription, waypoint coordinates should be inserted into the computers directly from the source documents.

(5) Since the initial stage of the flight can be very busy, consideration should be given to ensuring the navigation system waypoint transfer switches are placed in the "auto" position to facilitate outbound tracking and waypoint changeover during this period.

(6) With systems such as INS or Omega that navigate during ground operations, it is advisable to cross-check present position, taxi distance, or groundspeed (as appropriate), prior to takeoff to confirm proper system operation and to ensure that the present position remains accurate.

*h. **Equipment Preflight.*** In addition to operating procedures (checklists) to confirm proper system operation, care should be taken to ensure that the navigation equipment is properly programmed. This is a very important procedure and should not be rushed. All navigation information (coordinates or courses and distances) should be programmed by one crewmember and verified by another crewmember. Also, crews should verify that the same waypoint loading sequence is used for each system and indicate on the flight plan that the present position (if applicable) and waypoints have been entered and cross-checked. If time becomes a factor, it is more important to verify that the first two or three waypoints are correct than to rush through the procedure to insert as much information as possible. Consideration should be given to using another cross-check that compares the flight plan or charted distance between waypoints and the distance computed by the navigation system to detect programming or flight planning errors. This serves as a doublecheck on waypoint verification and will also reveal any error in the flight plan. A difference of more than + 2 NM or - 2 NM may indicate a programming or flight planning error.

*i. **Pretakeoff and Coast Out.*** Before takeoff, cross-check the computer present position to confirm proper system operation. At least two crewmembers should copy and confirm the oceanic clearance. Perform gross error check (accuracy check) to compare navigation computer position with VOR, VOR/DME, or NDB. Procedures are required for direct overflight of a navaid and for cases when the navaid is NOT directly overflown. The gross error should be recorded in the flight log. For Omega, guidance must be established for lane ambiguity resolution (refer to Section 7 of this Chapter). Outbound from gateway, cross-check VOR, VOR/DME or NDB course and distance information with navigational computers. Compass deviation check (INS only): use for DR and for determining which system is correct when there is disagreement between systems.

*j. **Within Range of the Outbound Gateway.*** Flights should not continue beyond the outbound gateway unless the required long-range navigation equipment is functioning properly. To confirm proper operation, certain cross-checks should be performed while within range of the gateway navaid. Since this may be the last positive position cross-check until the inbound gateway, the following practices may also provide valuable information for resolving any later navigation difficulties.

(1) All ATC oceanic clearances should be cross-checked by two crewmembers to ensure the clearance is copied correctly. Any flight plan waypoints that were revised in an ATC clearance should be crossed out and the revised coordinates entered in a legible manner. Prior to proceeding outbound from the gateway, the current ATC clearance should be compared to the flight plan, and the information in the navigation computers for the gateway and the subsequent waypoints should be verified.

(2) A gross error check is a position accuracy cross-check using normal airway facilities such as VOR, VOR/DME or NDB. The gross error check is usually accomplished by flying directly over the gateway (if possible) and subsequently establishing the aircraft on the outbound course using the gateway navaid. This check serves the following purposes:

(a) detects errors that may have accrued in position information since takeoff

(b) provides information that can be used to determine the most accurate system for use as a steering reference

(c) provides an opportunity to correct position information, if necessary

(d) can be used to confirm that the aircraft is established on the outbound course and is tracking toward the next waypoint

(e) can be used to confirm that the aircraft is proceeding according to the current ATC clearance

(3) When flight instruments are used for the display of either airways (VOR) information or information from the LRNS, the "radio/nav" switches should be left in "radio" position after passing over the gateway navaid until the radio information begins to become degraded. The switches should then be placed in the "nav" position.

(4) Consideration should be given to performing a compass deviation check on systems such as INS that use true heading information from sources independent of the aircraft compass system. The compass deviation can be determined by comparing the INS derived data later in the flight to determine the most accurate system should a divergence between systems occur. The compass deviations can be applied to the respective compasses to determine the actual magnetic heading. Local variation can be applied to the true heading of each INS to obtain the derived magnetic headings. The most accurate INS should be the one with a magnetic heading that compares the most favorably with the actual magnetic heading.

k. After Passing the Gateway. The system determined to be the most accurate during the gross error (TKE), check should usually be selected as the autopilot steering reference. When not being used for other purposes, this system should display present position. Routinely check cross-track, track angle error and distance to go. Display computer position coordinates and compare with ATC clearance to confirm that track centerline is maintained.

l. Approaching Waypoint. Within 2 minutes of each waypoint, both pilots should verify that the subsequent waypoint in the navigation display agrees with the current ATC clearance. Cross-check coordinates of the approaching waypoint and subsequent waypoints. Compare zone distance on the flight plan to that displayed on the navigation computer for the next leg. Compare computer flight plan ETA with ETA information displayed in navigation computers. (On some systems this cross- check may be more easily accomplished during waypoint passage.)

m. After Passing Each Waypoint. Approximately 10 minutes after passing each waypoint, the present position information on the navigation displays should be plotted on a navigation chart to confirm that the ATC clearance is satisfied (not applicable to most Doppler systems). Confirm that the navigation systems have switched to the next flight segment (leg change). Verify that the aircraft is tracking along the next flight segment (tracking outbound).

n. Approaching the Inbound Gateway. Certain preparations should be made for the transition from long-range navigation to airways navigation. The following practices are recommended:

(1) As soon as feasible, set up the navigation radios to receive the inbound gateway navaid.

(2) When the gateway navaid is providing reliable information, place the "radio/nav" switch in the "radio" position and steer the aircraft to acquire and maintain the proper inbound radial/bearing.

(3) Unless otherwise directed by ATC, the aircraft should be flown directly over the gateway.

(4) When over the gateway, record the position information from the navigation displays. This information can be used to confirm system accuracy. Compare VOR, VOR/DME, NDB course and distance information with that displayed in navigation computers. It is recommended that system accuracy computations be made after arrival to avoid conflicts with other cockpit duties during the critical periods of descent, approach and landing.

o. After Arrival. The individual navigation system errors and error rates, if applicable, should be computed and recorded for future reference. It is desirable to record this information in a document that remains aboard the aircraft to provide subsequent flightcrews with a recent history of system performance. This information may be used with most systems to predict individual system performance for future flights under similar circumstances. Additionally, this information may prove valuable to subsequent flightcrews for resolving navigation abnormalities, such as divergence between systems.

3. LONG-RANGE NAVIGATION PROBLEMS AND RECOMMENDED ACTIONS.

a. Background. Although the accuracy and reliability of the newer navigation systems are excellent, malfunctions and failures occasionally occur. When a malfunction occurs, flightcrews should guard against jumping to conclusions since hasty actions are seldom necessary and may further complicate the situation. Experience has shown that successful resolution of navigation difficulties in oceanic areas usually requires a thorough, thoughtful process that normally begins during preflight planning. The training program manuals and check airman program for air carrier operations should emphasize procedures to be followed in the event of partial and total instrument failure. Non air carrier operators should be prepared to demonstrate this emphasis in their training programs if requesting an LOA for oceanic operations in special airspace. The following guidance is presented for consideration when navigation difficulties are encountered or suspected.

b. Navigation Errors. Monitoring procedures used during oceanic operations indicate the frequency and course of navigation errors. Considering the thousands of flights that are made, errors are actually rather infrequent. Navigation systems are generally so reliable that there is some concern about overconfidence; therefore, crews should guard against complacency.

(1) Frequent causes of errors include the following:

(a) A mistake of one degree of latitude was made in inserting a forward waypoint.

(b) The crew was recleared by ATC, but forgot to reprogram the navigational system.

(c) The autopilot was left in the heading or decoupled position after avoiding severe weather, or was left in the VOR position after departing the last domestic airspace VOR. In some cases, this occurred after distractions by selective calling (selcal) or flight deck warning indications.

(d) The controller and crew had different understandings of the clearance because the pilot heard what he/she wanted to hear rather than what was actually said.

(2) Rare causes of errors include the following:

(a) The lat/long coordinates displayed at the gate position were incorrect.

(b) Because of a defective chip in an aircraft system, although the correct forward latitude was inserted by the crew, it "jumped" one degree.

(c) The aircraft was equipped with an advanced system that included all waypoint coordinates already on tape. The crew assumed the coordinates were correct, but one was not correct.

(d) Although the crew had the correct coordinates available, the information inserted into the system was from an incorrect company flight plan.

c. Detection of System Failure. In general, system failure is usually considered to have occurred when one of the following situations develops:

(1) a warning indicator is activated and cannot be reset;

(2) self-diagnostic or built-in test equipment (BITE) indicates that the system is unreliable;

(3) the position error over a known geographic location exceeds the maximum permissible tolerance established for a particular navigation system; or

(4) the system's operation is so abnormal that, despite the absence of warning or malfunction indications, the flightcrew considers the system no longer useful for navigation.

d. ***Detection of System Degradation or Malfunction.*** While system failures are usually straightforward, malfunctions or gradual system degradations are usually more difficult to detect. This is particularly true when only two systems are on board. Navigation difficulties of this type are usually detected by a divergence between the navigation systems, a situation that often occurs gradually. This factor may reduce the possibility of identifying the faulty system unless periodic cross-checking practices are diligently used. The following factors should be considered when attempting to identify a faulty system.

(1) Check the BITE codes for indications of system fault.

(2) For Omega, the system receiving the most stations and the best quality signals should generally be the most accurate.

(3) Review the gateway gross error check for indications of the most accurate system.

(4) If a regular record of system performance has been maintained and is available, a review of the record may give a clue as to which system is faulty.

(5) If possible, use VOR, automatic direction finder (ADF), DR, airborne radar, or other navaids to obtain a position fix.

(6) Cross-check heading, groundspeed, track, and wind information between systems and compare this information with the best known positive information such as position over a fix.

(7) Attempt to contact nearby aircraft to obtain wind or groundspeed and drift correction information that may identify the malfunctioning system.

(8) The compass deviation check discussed in Section 2 of this Chapter may provide a clue as to which system is faulty for systems such as INS.

Even though these steps are taken, a divergence between systems may occur, but the flightcrew may be unable to determine which system is at fault. When this occurs, the practices described in the following paragraph should be used.

e. Recommended Actions Following System Failure. After a system malfunction or failure has been detected, ATC should be informed that the flight is experiencing navigation difficulties so that separation criteria can be adjusted, if necessary. Reporting malfunctions to ATC is an ICAO requirement and compliance is required by FAR Part 91. If the failed system can be identified with a high degree of confidence and the other system appears normal, the best course of action may be to fly the normal system and carefully monitor its performance using any additional navaids available, including DR. In the unlikely event that a total navigation failure occurs and other aids are unavailable, the only action may be to fly by DR using the flight plan headings and times. Under these circumstances, flightcrews should continue to use all means available to obtain as much navigational information as possible. Flightcrews should be alert for visual sightings of other aircraft, since a hazard may exist due to an inadvertent deviation from the assigned track. In some cases, it may be possible to establish and maintain visual contact with another aircraft on the same track.

f. Recommended Action Following a Divergence Between Systems. Since a small divergence between systems may be normal, the significance of the divergence should be evaluated. In general terms, if the divergence is less than 10 NM, the best course may be to closely monitor system performance and continue to steer the system considered most accurate. If the divergence between systems is greater than 10 NM, one of the systems may be degraded. Therefore, attempts should be made to determine which system may be faulty. If the faulty system cannot be determined using the practices described in this section, and both systems appear normal, the action most likely to limit gross tracking error may be to position the aircraft so that the actual track is midway between the crosstrack differences for as long as the position uncertainty exists. ATC should be advised that navigation difficulties are being experienced so that separation criteria may be adjusted as necessary. Consideration should be given to abandoning this "split-the-difference" practice if the divergence exceeds the separation criteria currently in effect on the route of flight. If a divergence of this magnitude occurs and the faulty system cannot be isolated, the best course may be to fly by DR using the best known wind information. However, in some cases, the best known information may be flight plan headings and times.

4. PROVING TESTS AND VALIDATION FLIGHTS.

a. Introduction. FAR Parts 121 and 135 require evaluation of an operator's ability to conduct operations safely and in accordance with the applicable regulations before issuing an operating certificate or authorizing a certificate holder to serve an area or route. The testing method used by the FAA to determine an operator's capabilities are proving tests and validation flights. FAR 121.163 and 135.145 require operators seeking authority to operate certain types of aircraft to conduct proving tests before being granted operating authority. Proving tests consist of a demonstration of ability to conduct flights and to maintain the aircraft to the appropriate standards. Proving tests should not be confused with aircraft certification tests, which are tests conducted by the aircraft manufacturer to demonstrate the airworthiness of the aircraft. FAR 121.163 requires an operator to successfully conduct proving tests before the FAA authorizes the operation of each aircraft type. FAR 135.145 requires proving tests before the FAA authorizes the operation of each type of turbojet aircraft or each type of aircraft for which two pilots are required for VFR operations. FAR 121.93, 121.113, and 135.13(a)(2) require an operator to demonstrate the ability to conduct operations over proposed routes or areas in compliance with regulatory requirements before being granted FAA authority to conduct these operations. The FAA requires validation flights for authorization to add any areas of operation beyond the continent of North America and Mexico, and before issuance of operations specifications that authorize special means of navigation. Though proving tests and validation flights satisfy different requirements, it is common practice for operators to conduct both tests simultaneously. However, validation flights are important to consideration of oceanic operations.

b. Validation Flights. FAR 121.93, 121.113, and 135.13(a)(2) require operators to show the capability to conduct line operations safely and in compliance with regulatory requirements before being authorized to conduct those operations in revenue service. The most common method of validating an operator's capability is to observe flight operations. The FAA normally requires validation flights before issuing operations specifications granting authority to conduct operations beyond the populated areas of the North American continent. When the FAA conducts a validation flight, an in-depth review is conducted of the applicable portions of the operator's proposed procedures (especially flight following), training programs, manuals, facilities, and maintenance programs. There are four situations that require validation flights in association with approval of Class II navigation: initial approval; addition of an LRNS or a flight navigator; operations into new areas; and addition of special or unique navigation procedures. Validation flights are required when an operator proposes to conduct operations that require confirmation of the ability to operate an aircraft type within specified performance limitations. These limitations are based on the character of the terrain (or extended overwater areas), the type of operation, and the performance of the aircraft. Validation flights are also required when an operator proposes to conduct in-flight or ground maneuvers that require special operational authorizations.

c. Carriage of Revenue Passengers on Validation Flights. The FAR do not forbid the carriage of revenue passengers on validation flights. The operator may receive FAA authorization to carry revenue passengers during the validation flight when the proposed operation is similar to those in the applicant's previous experience. However, carriage of revenue passengers is normally not permitted during validation flights in the following situations:

(1) when the operator is seeking initial approval to conduct Class II navigation in any airspace designated as a special area of operation;

(2) when the operator is seeking approval to conduct Class II navigation by an LRNS or by using a flight navigator not previously approved for that means of navigation;

(3) when the operator is seeking approval to conduct Class II navigation by means of a long-range navigation procedure that has not previously been approved for that operator; and

(4) when the operator has not previously operated a specific aircraft type in operations requiring special performance authorization.

d. Special Areas of Operation. Certain areas of Class II airspace are considered special operating airspace for purposes of validation. These areas include the following:

(1) extensive areas of magnetic unreliability;

(2) NAT MNPS airspace and Canadian MNPS airspace;

(3) Central Pacific (CEPAC) composite airspace and Northern Pacific (NOPAC) airspace;

(4) Arctic Ocean and Antarctic airspace; and

(5) politically sensitive areas of operation.

e. Special Navigation Procedures. Validation flights are normally required when an applicant proposes to use navigation procedures not previously demonstrated. These procedures include the following:

(1) pilotage, including DR;

(2) flight navigator procedures;

(3) celestial navigation;

(4) pressure pattern and Bellamy drift DR;

(5) free gyro or grid procedures; and

(6) any combination of the preceding procedures.

f. Other Situations Requiring Validation Flights. Validation flights may also be required for special operational authorizations and special performance authorizations. Operators who require additional information on validation flights are encouraged to contact their local FAA flight standards district office (FSDO).

5. DOPPLER NAVIGATION - SPECIAL PROCEDURES.

In addition to the general navigational practices and procedures contained in this Chapter, the following information applies to Doppler navigation systems. A Doppler system (sensor plus computer) is a semiautomatic DR device that is less accurate than an INS or Omega system. A means of updating the Doppler is usually required if acceptable position accuracy is to be achieved on long- range flights. INS, Omega or Loran-C may be used as the updating reference for the Doppler system. The following factors should be considered when using a Doppler navigation system.

a. Compass Accuracy. Most Doppler systems measure groundspeed to an accuracy of about one percent and drift angle to a fraction of a degree. Its directional reference, however, is the aircraft's compass system. If the overall Doppler/compass system is to be usefully accurate, the compass should be swung and compensated so that its error does not exceed one degree on any heading.

b. Preflight. During preflight, the flight plan course and distances for those flight segments where Doppler navigation is required should be verified. Normally, the courses should be determined to the nearest one tenth of a degree and the distances to the nearest NM. This is routinely accomplished by using course and distance tables designed for this purpose. Extreme care and accuracy are important considerations during this cross-check. If the Doppler system is to be used for navigation from takeoff, both "A" and "B" stages should be programmed and the "auto/manual" switch should be placed in "auto." Also, the proper position for the "land/sea" switch should be determined since this affects the accuracy of the groundspeed information.

*c. **When Approaching the Outbound Gateway.*** The Doppler system performance records for recent flights over similar routes should be reviewed to determine if a system deviation correction should be applied. If the records indicate that a deviation correction may be necessary, apply the correction to the Doppler system used. Both pilots should verify that the outbound course and distance programmed in the active stage conforms to the currently effective ATC clearance. Unless otherwise required by ATC, the aircraft should be flown directly over the gateway fix to obtain the most accurate starting position practical. When directly over the gateway, both pilots should ensure that the Doppler computers have been activated and that the proper stage is selected. The aircraft should be established on the outbound track by using the gateway navaid. Once this is accomplished, the gross error cross-checks discussed in Section 2 above should be accomplished. Consideration should be given to using an additional cross-check. This is accomplished by applying drift angle to the compass heading and comparing the result (actual track) to the flight planned magnetic course.

*d. **Updating the Doppler Computer.*** Since Doppler systems (in a magnetically slaved model) fly a "rhumb line" (curved track) and most navigation charts commonly used reflect "Great Circle" (straight tracks), certain precautions should be observed when updating Doppler systems. Although a great circle course and a rhumb line course begin and end at common points, the two courses diverge between the waypoints. This divergence normally reaches a maximum near the midpoint of the leg, and the magnitude of the divergence increases as the latitude and distance between waypoints increase. Under normal circumstances, position fixes for Doppler updating purposes should be obtained within 75 NM of a waypoint to minimize the possibility of inducing an error into the Doppler system due to the rhumb line effect. This practice should be applied to both manually obtained and automatically obtained position fixes. When Doppler systems are used in the grid (free gyro) mode, the Doppler track will approximate a great circle, and the rhumb line effect is not a factor. Under these conditions, the updating restrictions detailed above are not normally applicable.

6. INS NAVIGATION - SPECIAL PRACTICES AND PROCEDURES.

*a. **Preflight.*** Since INS is a DR device and not a position-fixing device, any error induced during alignment will be retained and possibly incremented throughout the flight unless it is removed through updating procedures. Therefore, during preflight, care should be exercised to ensure that accurate present position information is inserted into the INS. Although most INS will automatically detect large errors in present position latitude during alignment, large errors in present position longitude may exist without activating a warning indication. When cross-checking present position coordinates, be alert for the correct hemispheric indicator (i.e., N, S, E, W) as well as the correct numerical values. Since most INS cannot be realigned in flight, special procedures such as ground realignment may be required to correct a significant error in present position. If the INS in use has the capability of "gang-loading" (simultaneous loading) by use of a remote feature, care should be taken so that any data entered by this method is cross-checked separately on each individual INS to detect data insertion errors. The INS software identification and modification status codes should be verified to ensure that the proper equipment is installed and the appropriate operating checklist is used. The operating checklists should include a means of ensuring that the INS is ready to navigate and that the navigation mode is activated prior to moving the aircraft. Any movement of the aircraft prior to activating the navigation mode may induce very large errors that can only be corrected by ground realignment. After the system is placed in the navigation mode, the INS groundspeed should be checked when the aircraft is stationary. An erroneous reading of more than a few knots may indicate a faulty or less reliable unit. If this occurs, a check should be made of the malfunction codes.

b. In-Flight Updating. INS are essentially accurate and reliable, but it is possible to introduce errors in an attempt to improve accuracy by in-flight updating. On the other hand, INS errors generally increase with time and are not self-correcting. If large tracking errors are permitted to occur, aircraft safety and separation criteria may be significantly degraded. These factors should be considered in any decision relative to in-flight updating. As a guide to flightcrews, some operators consider that unless the ground facility provides a precise check and unless the error is fairly significant (e.g., more than 6 NM or 2 NM/hour), it is preferable to retain the error rather than update.

7. OMEGA INFORMATION.

This section addresses only dual Omega installations. However, operators should be aware that if an operation requires two LRNS and one of the systems used is an Omega system, all requirements specified for Omega as the sole means of navigation must be met. Installations which propose to use one Omega system in combination with one or more other types of sensors or units should be evaluated on an individual basis, considering the performance of the individual systems as discussed in other sections of this Chapter.

a. Background. Omega is a radio navigation system that uses a worldwide network of VLF signals from eight ground-based transmitters. The principal attributes of the Omega system are the high degree of signal stability and low signal attenuation that produce reliable position information over great distances. Various methods of signal processing are used by different manufacturers to develop position information and navigation guidance (rho-rho, hyperbolic, single frequency, 3.4 KC tracker, etc.). Because of these variations in processing methods, each design will be evaluated and approved individually. When Omega systems meet the provisions described below, they may be used as the sole means of long-range navigation for operations in oceanic and/or remote land areas where adequate accuracy and reliability have been demonstrated. U.S. Navy VLF communication stations may be used to supplement Omega navigation systems. However, the U.S. Navy VLF stations are not dedicated to navigation and their signals may not be available at all times. Therefore, systems approved in accordance with this AC should be capable of operating on Omega systems alone.

The approval process is divided into two parts. The first part deals with approval under FAR Part 25 and the second part deals with operational approval under FAR Part 121. Guidance concerning compliance with FAR Part 91 regarding NAT MNPS airspace is contained in Chapter 3, Section 1 of this AC.

b. Airworthiness Approval. Applicants desiring airworthiness approval of dual Omega navigation systems in accordance with this AC should contact the appropriate FAA Regional Engineering and Manufacturing Office at least 30 days prior to start of the evaluation for processing a supplemental type certificate (STC) or type certificate (TC) amendment. A dual Omega installation includes two receiver processor units, two control display units (CDU), and two antennas.

c. Operational Approval. FAR Part 121 requirements for en route navigation facilities are contained in FAR 121.103 and 121.121. Air carrier applicants desiring operational approval for use of dual Omega systems should contact the FSDO charged with the administration of their operating certificate a minimum of 30 days prior to the proposed start of evaluation flights. FAR Part 91 operators desiring approval of dual Omega systems for flights in MNPS airspace should contact the FSDO nearest their principal base of operations to obtain an LOA. Requests should include evidence of FAA airworthiness approval of the system, a description of the system installation, and the operator's experience with the system. Prior to presenting the initial request, an operator should have accumulated sufficient experience with the equipment to establish a history of the accuracy and reliability of the proposed system. The applicant may include previous or related operational experience of other operators who have used the same equipment on the same type aircraft, and operational experience gained during type certification or supplemental type certificate of the aircraft. Once a particular system has received an equipment approval, subsequent evaluation and approval in the same type of aircraft installations may be adjusted to avoid duplication of part of the accuracy and reliability data gathering process involved in the issuance of the original approval. A comprehensive summary of any flight experience that establishes a history of adequate signal coverage (during day or night operations), accuracy, lane ambiguity detection/resolution, and in-service reliability should be provided to show competency in the proposed operation and maintenance of the equipment.

The applicant must present proposed revisions to the operation manual, describing all normal and abnormal system operating procedures and flightcrew error protection procedures including cross-checking of data insertion, detailed methods for continuing the navigation function with partial or complete Omega system failure, reacquiring the proper lane after any power outages, and procedures for continuing operation in the event of a divergence between systems. The applicant must also present proposed revisions to the minimum equipment list (MEL) concerning Omega, with appropriate justification. The applicant must present a list of operations to be conducted using the system including an analysis of each operation with respect to signal reception for ground synchronization and en route operation, signal absorption by the Greenland Icecap, sufficient redundancy of signal coverage to permit continued operation during station outages, procedures for operating in areas of magnetic compass unreliability (if applicable), availability of other en route navaids, and adequacy of gateway facilities to support the system. (For the purpose of this AC, a gateway is a specific navigation fix where the use of LRNS commences or terminates.) The operator must develop a procedure for timely dissemination of Omega NOTAM information to crewmembers. The operator must also develop an outline of the maintenance program for the equipment, including training of maintenance personnel, positioning of spares and test equipment, maintenance manual revision procedures (if applicable), and the other means of compliance with the requirements of FAR Part 121, Subpart L.

The Omega navigation system should be checked in-flight to determine that the design and installation criteria are met. All modes of operation should be functionally checked. The airplane flight manual procedures should be evaluated in-flight, including abnormal and emergency procedures. This evaluation should include reinitialization, lane ambiguity resolution, etc., during normal and adverse conditions. Interfaced equipment should be evaluated to ensure proper operation. Normal flight maneuvering should include 180 degree turns to verify dynamic response. An applicant for airworthiness approval should provide data from sufficient flights in the area of intended use to show that the Omega navigation system can meet the accuracy requirements stipulated for LRNS in FAR 37.205, technical standard order (TSO) C-94, and Radio Technical Commission for Aeronautics (RTCA) DO-164, Section III, paragraph 3.8. Consideration should be given to time of day, season, station outages, station geometry, and poor signal-to-noise ratio.

(1) It should be demonstrated that operation of the system does not impose an unacceptable workload in a normal flight environment on the flightcrew. This aspect should receive careful scrutiny relative to crew workload during power outages, DR operations, and detecting/resolving lane ambiguities.

(2) The DR mode should be evaluated to determine the maximum period for which interim use is permissible. The information should be included in the airplane flight manual.

d. Ground Evaluation. After installation, an operational/functional check should be performed to demonstrate compatibility between the Omega system and aircraft electrical and electronic systems. This test should be conducted with all electrical/electronic equipment operating normally on aircraft power. A ground location should be selected that minimizes the presence of external electromagnetic interference. In addition, it should be demonstrated that the Omega equipment will not adversely affect other systems to which it may be connected; i.e., air data, autopilot, flight director, and compass system. The Omega velocity and heading (or track) information presented on the control display unit (CDU) and other interfacing instruments should have reasonable comparison to the primary indications on other flight deck instruments. During these tests, the primary velocity and heading inputs to the Omega system should be slewed through their operating range to ensure compatibility of input to interfaced equipment. This evaluation may be conducted in-flight. Displays of all data basic to the installed Omega systems should be demonstrated to show no instability or discontinuity utilizing those stations identified by the system as usable and necessary for navigation. This evaluation may be conducted in-flight.

e. Evaluation and Final Approval. Prior to final approval for the use of Omega as a sole means of long-range navigation, a thorough evaluation of an operator's training program and a flight evaluation by an FAA inspector will be required. This flight evaluation should be requested on the operator's application for the use of Omega as a sole means of long-range navigation.

(1) The evaluation by an FAA inspector will include the adequacy of operating procedures and training programs; availability of terminal, gateway, area, and en route ground-based navaids; operational accuracy; equipment reliability; and acceptable maintenance procedures. Omega equipment operations should be closely analyzed to ensure that an unacceptable workload is not imposed upon the flightcrew by use of the Omega equipment in normal and abnormal operations.

(2) After the evaluation is completed, FAA approval is indicated by issuance of operations specifications for air carriers and by an LOA for other operators who desire to fly in airspace where an authorization is required. The operations specifications (or amendments thereto) authorizing the use of dual Omega as a sole means of long-range navigation in the areas in which operations were demonstrated by an air carrier will limit the operations to areas where compliance with FAR Part 121 or FAR Part 135 requirements were demonstrated. Requirements for LOA's are detailed in Chapter 3 of this AC.

(3) The operations specifications should contain applicable limitations or special requirements needed for particular routes or areas and, where necessary, list a sufficient number of Omega ground transmitters required to be in operation to provide the necessary amount of signal redundancy.

f. Minimum Functions Necessary When Used for Position Fixing and Sole Means of Navigation. Dual independent Omega navigation systems used as a position-fixing device or position- keeping device and sole means of navigation should meet the performance requirements of TSO C-94, "Airborne Omega Receiving Equipment" and Section 3 of RTCA Document No. DO-164 titled "Minimum Performance Standards Airborne Omega Receiving Equipment" dated March 19, 1976. When installed, the system should provide a means of entry for at least the following data inputs and functions:

(1) present position (initializing, reinitialization and update);

(2) waypoints;

(3) heading, wind and true airspeed (TAS); or track and groundspeed; or other external information required for operation in the secondary or direct ranging mode;

(4) time;

(5) date;

(6) deselection and reselection of any station (automatic deselection and reselection is acceptable if shown to be effective and reliable); and

(7) lane ambiguity resolution. Automatic lane ambiguity resolution is acceptable if shown to effective and reliable.

g. System Displays. If the equipment is to be operated by the pilot(s), the system controls and data display should be visible to, and usable by, each pilot seated at a pilot duty station. The system controls should be arranged to provide adequate protection against inadvertent system turnoff. The system should also provide a means of displaying the following information:

(1) present position

(2) time

(3) date

(4) synchronization status

(5) station(s) deselected - station(s) selected

(6) time and position recall in event of power failure for up to 7 minutes

(7) annunciation when system is not operating in the primary Omega navigation mode

(8) a visual or aural warning of system failure, malfunctions, power interruption, lack of synchronization, or operation without adequate signals

(9) waypoint coordinates

(10) bearing and distance between waypoints

(11) deviation from desired course

(12) distance and time to go to selected waypoint

(13) track angle and/or error

(14) drift angle

(15) wind, TAS and heading; or track and groundspeed

(16) stations currently being installed to determine position

(17) steering information on the horizontal situation indicator (HSI) or equivalent

(18) confirmation of data insertion

h. Failure Protection. Normal operation or probable failure of the airborne Omega navigation system should not derogate the normal operation of interfaced equipment. Likewise, the failure of interfaced equipment should not render an Omega system inoperative.

i. Environmental Conditions. The Omega equipment should be capable of performing its intended function over the environmental ranges expected to be encountered in actual operations. RTCA Document No. DO-160 should be used for appropriate guidelines.

j. Antenna Performance. The antenna design and installation should minimize the effects of precipitation (p) static and other noise of disturbances.

k. Dynamic Responses. The system operation should not be adversely affected by aircraft maneuvering or changes in attitude encountered in normal operations.

l. Preflight Test. A preflight test capability should be provided to inform the flightcrew of system status.

m. Aircraft Electrical Power Source. One Omega system should be installed so that it receives electrical power from a bus that provides maximum reliability without jeopardizing essential or emergency loads assigned to that bus. The other Omega system should be installed so that it receives power from a different bus that provides a high degree of reliability. Any electrical power transient, including in-flight selection of another source of power, should not adversely effect the operation of either Omega system. After power interruption of 7 + or - 2 seconds, the Omega equipment should automatically resynchronize and resume normal operation within 3 minutes without operator intervention. After a power interruption of greater than 7 seconds and up to 7 minutes, the Omega equipment should either automatically resume normal operation (including proper lane resolution) or retain the last "power-on" Omega equipment position and time for display on command. A battery, if shown to be of sufficient capacity, may be used to provide power for this function. The Omega navigation system should not be the source of objectionable electromagnetic interference, nor be adversely affected by electromagnetic interference from other equipment in the aircraft.

n. Steering Outputs. The Omega system should provide steering outputs to the autopilot and/or HSI or equivalent so that the equipment interface is compatible.

o. Airplane Flight Manual. The airplane flight manual should contain the following information regarding the Omega equipment:

(1) normal procedures for operating the equipment

(2) equipment operating limitations

(3) emergency/abnormal operating procedures (if applicable)

(4) procedures for reacquiring the proper lane after power outages

p. Demonstration of Performance. An applicant for approval of dual Omega navigation system installation should ensure that the installed Omega system can demonstrate adequate performance by a combination of ground and flight evaluations defined in the following two paragraphs.

q. Equipment and Equipment Installation. Omega navigation systems should be installed in accordance with the airworthiness approved system installation requirements. If evaluation flights are made for operations requiring an LRNS, a navigation system already approved for the operator under FAR Part 121 should be used as the primary means of navigation.

r. Omega Training Programs. The training program curriculum must include initial and recurrent training and checking for those crewmembers who will be operating the Omega equipment. Initial training programs should include the following:

(1) Instruction regarding responsibilities of flight crewmembers, dispatchers and maintenance personnel.

(2) For the flightcrews who are to operate the Omega equipment, instruction in the following:

(a) description of the Omega network, airborne system description, limitations, and detection of malfunctions;

(b) normal operating procedures including preflight procedures and testing, data insertion and cross-checking, en route procedures including periodic cross-checking of system position display and comparison between systems;

(c) updating procedures, if applicable;

(d) operations in areas of magnetic compass unreliability, if applicable;

(e) abnormal and emergency procedures, including airborne conditions, procedures for assessing and resolving divergence between systems, and procedures for reacquiring the proper lane in case of power outages in excess of 7 seconds;

(f) a review of navigation, including flight planning and applicable meteorology as necessary, if not addressed in another approved training course; and

(g) compilation of terminal and/or gateway system errors.

(3) Procedures for operating the Omega navigation system should be incorporated into the recurrent training program for those crewmembers who are to operate the Omega equipment.

(4) For flight crewmembers without previous Omega experience, the training and qualification program should include an in-flight qualification check based on the training program. Accomplishment of such training during evaluation flights is acceptable. Sufficient flightcrews considered fully qualified by the applicant should be observed in-flight by an FAA inspector to determine the overall effectiveness of the training and qualification program. Flightcrews possessing current operational experience with the installed Omega equip-

ment need only receive training specifying any differences in procedures created by using Omega as a sole means of long-range navigation, if applicable.

(5) Annual line checks as required by FAR 121.440 should include a check of Omega operating procedures. Required annual checks of flight navigators, if they are to operate the Omega equipment, should also include a check of these procedures.

s. ***Accuracy and Reliability.*** The applicant should show the following:

(1) That an adequate in-flight service reliability rate stated in terms of in-flight mean time between failures (MTBF) is in existence, with no significant unresolved problems remaining.

(2) That in the process of proposed operation, the Omega navigation system meets the accuracy requirements stipulated for Omega navigation systems. If the proposed system is to be operated in areas with special navigation requirements (e.g., MNPS airspace), the accuracy required for those areas must also be demonstrated. Systems that become exceedingly inaccurate without displaying a warning indication should be included in the accuracy accounting. Systems that display a failure warning and are subsequently shut down or disregarded should be included in the accounting of failed systems but excluded from the accuracy accounting.

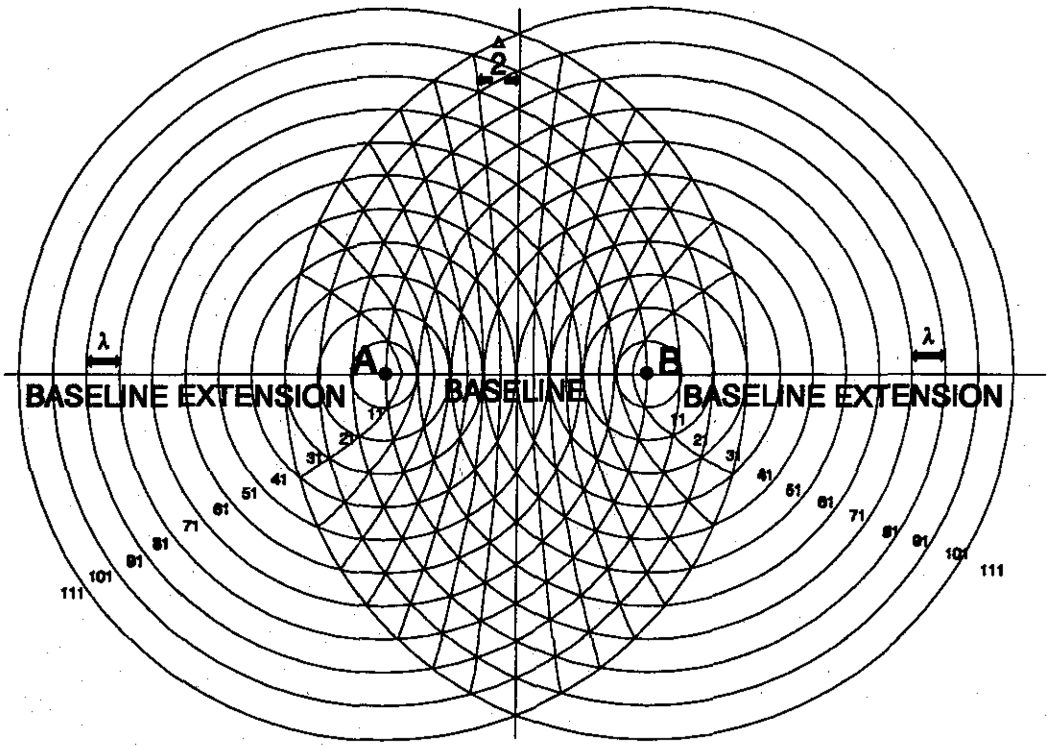
(3) That Omega navigation systems which are subject to lane ambiguity have a reliable means of reacquiring the proper lane.

(4) That the Omega sole means system can meet navigation separation requirements and have sufficient signal redundancy to continue navigation during Omega station outages. Equipment having the capability to process the U.S. Navy VLF signals may utilize that feature to refine Omega information to assist in meeting this stipulation.

(5) That within the proposed area of operation, navigation capability is not predicated on the DR mode, and that any interim operation in DR does not degrade navigation accuracy and reliability beyond that required to comply with ATC requirements.

t. ***Special Practices and Procedures.*** Since the CDU's of most Omega systems are similar in appearance to those used for INS, persons familiar with INS may have a tendency to assume that Omega has similar performance characteristics. This assumption could create significant problems. INS is a precision DR device which is wholly self-contained within the aircraft and has a nominal position degradation of about 1 mile per hour of flight. Omega, in contrast, continuously resolves aircraft position by processing radio signals received from a global network of transmitters. It is therefore possible for Omega to be affected by signal propagation disturbances and abnormally high local radio noise levels. In normal operation, Omega provides a position accuracy of 1 to 3 NM which, unlike INS, does not degrade with increasing flight time. However, most Omega systems compute position in signal "lanes," which are a function of the signal wavelength. A disturbance of sufficient magnitude may force the computed position into an adjacent lane and thereby cause an error which is measured in multiples of the basic lane width. This occurrence is termed a "lane slip." Most Omega systems possess an auxiliary operating mode termed "lane ambiguity resolution" (LAR). The purpose of this mode is to correct the lane slip by returning the present position to the correct lane. Details of lane ambiguity follow.

FIGURE 8-1. OMEGA LANES FORMED BY HYPERBOLIC ISOPHASE CONTOURS



*u. **Omega Lanes Formed by Hyperbolic Isophase Contours.*** (Figure 8-1) The set of isophase contours between a station pair forms a series of lanes, each corresponding to one complete cycle of phase difference. In the direct ranging mode, lanes are formed by concentric rings of zero phase with a constant interval of one wavelength (16 NM at 10.2 kilohertz (kHz)). In the hyperbolic mode, one complete cycle of phase difference occurs every one half wavelength. Therefore, 10.2 kHz hyperbolic lanes are 8 NM wide on the baseline, and gradually diverge as the distance from the baseline increases. Each lane, or cycle of the phase, is divided into hundredths of a lane called centilanes (cel). The phase difference between station pairs, measured in hundredths of a cycle or centicycles (cec), gives a hyperbolic line of position (LOP) within an Omega lane. (The term cel refers to the fraction of the charted lane. The term cec refers to the phase measurement as a percentage of a cycle. At 102 kHz, they are numerically equal and often used interchangeably, with cec used most commonly.) For example, in Figure 8-2 phase differences of 20 cec and 50 cec between stations A and B would give LOP's as shown. Twenty cec would indicate an LOP 20 percent of a lane width from the lane boundary; 50 cec would indicate an LOP 50 percent of a lane width from the lane boundary. Fractional lane widths are taken from a given lane boundary toward the direction of the station with the letter designation occurring later in the alphabet (from the "lower" letter to the "higher" letter). Since the same phase difference will be observed at any point on an LOP, a second LOP must be taken using another station pair to obtain a position fix. In Figure 8-3, the phase difference A-B is 50 cec, and the phase difference B-C is 80 cec. The intersection of these LOP's gives a position fix. In actual practice, propagation corrections (PPC) would be applied to the observed phase difference readings before plotting.

FIGURE 8-2. PHASE MEASUREMENT WITHIN AN OMEGA LANE

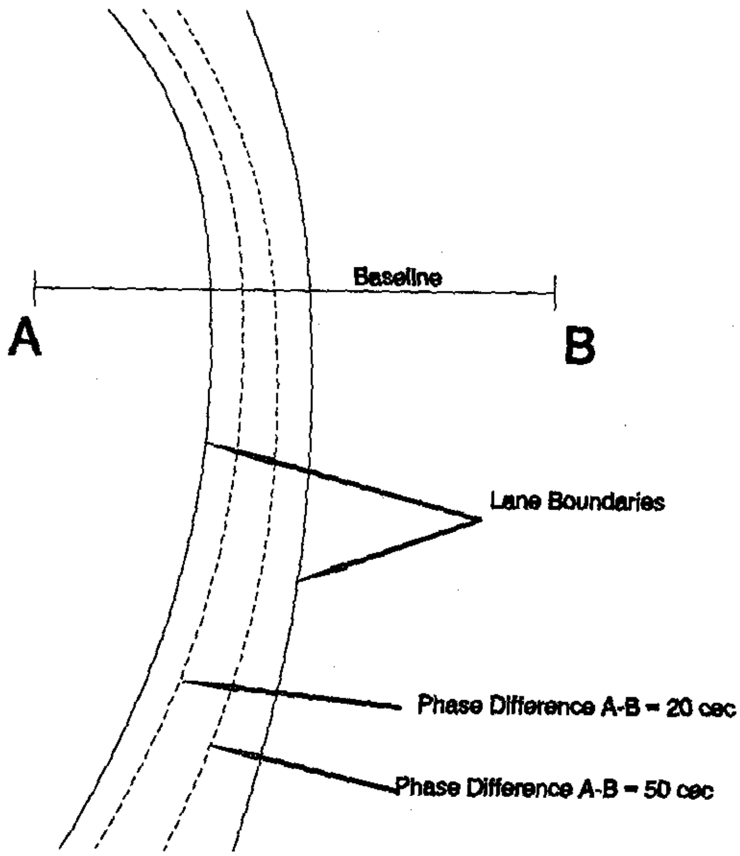
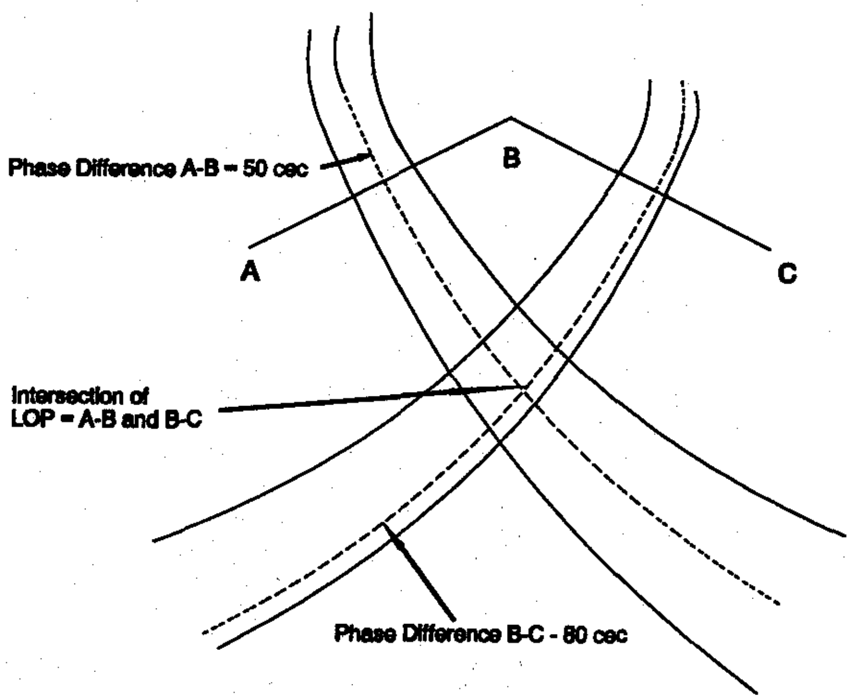


FIGURE 8-3. POSITION FIX BY INTERSECTION OF HYPERBOLIC LOP'S



v. ***Lane Ambiguity.*** In the preceding examples, it is assumed that the aircraft's position is known to within a particular set of lanes. Because of the cyclic nature of the phase differences, the same phase difference can be observed in any lane. This is known as lane ambiguity. On the baseline between station pairs, there are about 600 10.2 kHz lanes. Each lane is 8 NM wide on the baseline, and diverges to about 12-15 NM near the limits of coverage. The navigator must know which of these lanes the aircraft is in before plotting a fix. Lane ambiguity can be resolved by three methods. The preferred method is to set the receiver's lane count at a known location, such as the point of departure. As the aircraft moves across lane boundaries, the receiver will automatically update the lane identification numbers, allowing the navigator to plot fixes with phase difference measurements in a known lane. If the lane count is lost, the lane count must be reset based on DR, celestial fix, or other means. The third alternative is to derive a course lane using multiple frequencies.

The preceding examples have considered only 10.2 kHz. Many receivers are capable of using the other Omega frequencies for various purposes. One such purpose is lane ambiguity resolution. There is a 3:4 frequency ratio between 10.2 kHz and 13.6 kHz. This relationship also applies to other wavelengths. Three 10.2 kHz wavelengths are the same length as four 13.6 wavelengths (Figure 8-4), or 24 NM on the baseline in the hyperbolic mode (48 NM in the direct ranging mode). A wavelength of 24 NM would correspond to a frequency of 3.4 kHz, which is the difference between 10.2 and 13.6 kHz. The receiver can synthesize a 3.4 kHz Omega signal by combining the 10.2 and 13.6 kHz signals. The 10.2 kHz lane numbers, which are evenly divisible by 3, form the boundaries of 3.4 kHz course lanes (Figure 8-5). The 3.4 kHz phase differences can be plotted in these course lanes. The resulting fix is then used to reset the 10.2 kHz lane count.

FIGURE 8-4. USING FREQUENCY DIFFERENCES TO DERIVE COURSE LANES

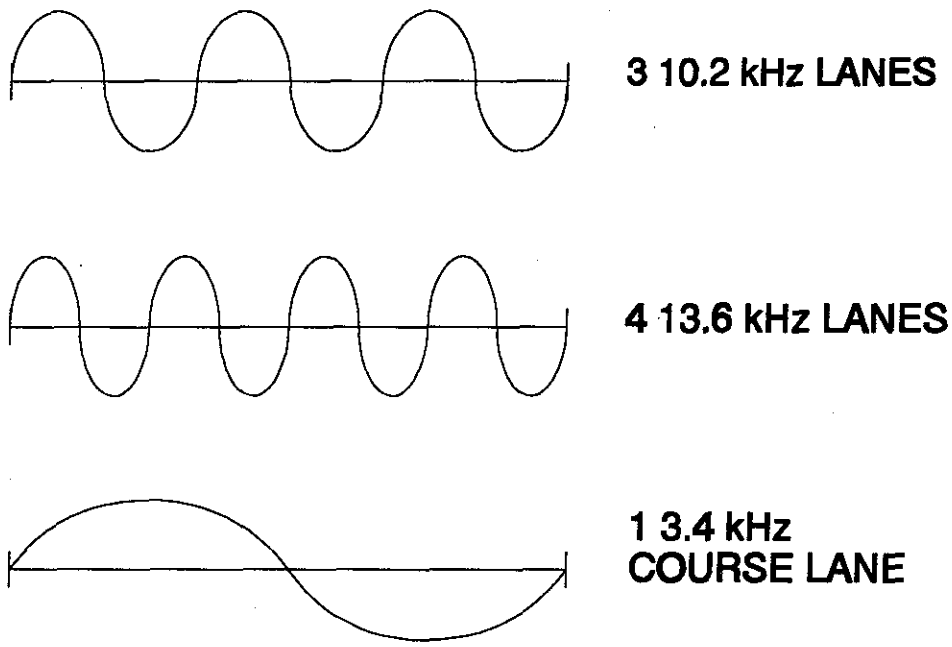
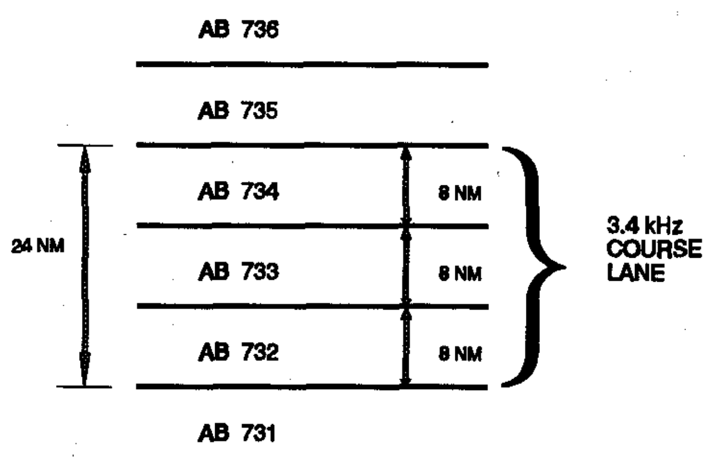


FIGURE 8-5. COURSE LANE BOUNDARIES IN THE HYPERBOLIC MODE



w. ***Omega Navigation System Center.*** The Omega Navigation System Center (ONSCEN) is the Coast Guard unit responsible for the operational control of Omega. ONSCEN is staffed on weekdays between 7:00 a.m. and 3:30 p.m., eastern time. During these hours information on Omega, including the current system status, scheduled off-air periods, and any navigational warnings in effect may be obtained by calling (703) 866-3800. At other times a command duty officer (CDO) is on watch and can be contacted by calling the same number; a recorded message will give the name and telephone number of the CDO. Written inquiries may be addressed to: Commanding Officer, Omega Navigation System Center, 7323 Telegraph Road, Alexandria, VA 22310-3998. A recorded message giving the current status of Omega is available at any time by calling (703) 866-3801. This recording gives the dates and times of scheduled off-air periods, any navigational warnings in effect due to signal disturbances, and any other important system information. Routine Omega status reports and navigational warnings are also available through the following means.

(1) Telex/mail. Omega status reports are issued weekly by telex or mail to users of Omega equipment. Navigational warnings are not issued by telex or mail. Write to ONSCEN at the address given above.

(2) Radio broadcast. The U.S. Department of Commerce (DOC), National Institutes of Standards and Technology, broadcasts Omega status advisories on radio stations WWV, Fort Collins, CO and WWVH, Kauai, HA on 2.5, 5, 10, and 15 megahertz (MHz). WWV also broadcasts on 20 MHz. Omega status advisories are broadcast at 16 minutes past each hour on WWV, and at 47 minutes past each hour on WWVH. These advisories contain dates for scheduled off-airs and any navigational warnings in effect. Because each announcement is limited to 40 seconds, the specific times for each off-air period may not be given.

(3) NOTAM. When alerted by the Coast Guard, the FAA issues NOTAM's to warn of signal disturbances or unscheduled off-air periods. Airmen should consult their local FAA office for details regarding the issuance of Omega NOTAM's.

x. ***Aviation Use of Omega.*** Whereas INS position errors normally accrue gradually with elapsed flight time, most Omega errors occur suddenly and are usually multiples of the basic lane width. Effective cross-checking procedures should be accomplished at regular intervals and LAR or in-flight updating should be initiated when the position accuracy is in doubt. In addition to the general practices and procedures contained in Section 1, above, the following recommendations apply to Omega systems.

(1) Preflight.

(a) Crews should be alert for any NOTAM's affecting the operational status of the individual Omega transmitters, particularly for possible abnormal operation. Deselection of any station reported to be in abnormal operation should be considered at the onset of the flight. Also, crews should be alert for any NOTAM's relating to the propagation disturbances, such as sudden ionospheric disturbances, sudden phase anomalies, or polar cap anomalies, which may affect Omega positioning accuracy. Scheduled Omega status broadcasts on station WWV should be monitored as a means of obtaining current Omega information.

(b) The Omega software and modification status codes should be verified by flightcrews to ensure that the proper equipment is installed and that the appropriate checklist is available and is used.

(c) At certain ground locations, particularly at congested terminals, abnormally high radio noise levels may adversely affect Omega. For example, synchronization may take longer than normal or the inserted ramp coordinates may drift after insertion. Synchronization or DR warning lights usually indicate this situation. This problem normally disappears, if the Omega equipment is serviceable, shortly after the switch to aircraft power or after the aircraft is moved from the gate. Care should be exercised during taxi, since abrupt turns may cause a momentary loss of signals which could affect system accuracy. It is good practice to cross-check present position coordinates or taxi distance before takeoff to detect any errors which may have occurred since initialization.

(2) In-Flight Updating. The same considerations basic to updating an INS also apply to Omega due to the normal accuracy and reliability of these systems. However, in addition to the capability to update over a navaid, most Omega systems are capable of performing an LAR if certain signal strength and station geometry requirements are met. Unless an apparent Omega error exceeds 6 NM, a lane slip may not necessarily have occurred and LAR or updating is not normally recommended. If an LAR appears to be necessary, the LAR should be initiated on only one system at a time so that the other system remains unaffected for use as a cross-check. The LAR should be attempted first on the system believed to be the least accurate.

*y. **Navigation Errors by Omega Equipped Aircraft.*** If a navigation error is discovered by a crew of an Omega equipped aircraft, or if a crew of an Omega equipped aircraft is notified of a navigation error by ATC, a report containing the information listed in Figure 8-6 should be submitted to the FAA. This information should be sent by mail or facsimile (fax) to the FSDO nearest the aircraft's base of operation or, if applicable, to the FSDO that holds the operator's operating certificate.

FIGURE 8-6. NAVIGATION DEVIATION REPORT FOR OMEGA EQUIPPED AIRCRAFT

1. Details of aircraft and reported error.

   Name of operator:

   Aircraft identification:

   Date/time of observed error:

   Flight level (FL):

   Position (lat/long):

   Approximate cross-track deviation (NM):

2. Was Omega being used as the primary means of navigation and steering guidance?

3. Do you consider failure of, or difficulty with, the Omega system as a contributory cause of the deviation? (If not, do not complete items 5-10)

4. Manufacturer of Omega equipment, type of equipment, most recent modification date.

5. Give details of cleared track within NAT oceanic airspace.

6. Give details of any problems experienced with Omega, together with the approximate geographic location.

7. Give details of Omega/VLF signals used and received signal strength.

8. Have there been previous difficulties with the Omega installation? If so, give details.

9. Have any faults been discovered during general checks/maintenance work?

10. What rectification work has been performed?

11. Please provide any additional information that you feel is relevant.

8. GLOBAL POSITIONING SYSTEMS (GPS) GENERAL INFORMATION.

a. GPS Navigation. The GPS is a satellite-based radio navigation system that uses precise range measurements from GPS satellites to determine a precise position anywhere in the world. The GPS constellation consists of 24 satellites in various orbital planes approximately 11,000 nautical miles (NM) above the earth. The satellites broadcast a timing signal and data message that the airborne equipment processes to obtain satellite position and status data, and to measure how long each satellite's radio signal takes to reach the receiver. By knowing the precise location of each satellite and precisely matching timing with the atomic clocks on the satellites, the receiver can accurately measure the time the signal takes to arrive at the receiver and thus determine the satellite's precise position. A minimum of three satellites must be in view to determine a two-dimensional position. Four satellites are required to establish an accurate three-dimensional position. GPS equipment determines its position by precise measurement of the distance from selected satellites in the system and the satellite's known location. The accuracy of GPS position data can be affected by various factors. Many of these accuracy errors can be reduced or eliminated with mathematics and sophisticated modeling, while other sources of errors cannot be corrected. The following are examples of those errors which cannot be corrected:

(1) Atmospheric propagation delays can cause relatively small measurement errors, typically less than 100 feet. Ionospheric propagation delays can be partially corrected by sophisticated error-correction capabilities.

(2) Slight inaccuracies in the atomic clocks on the satellites can cause a small position error of approximately 2 feet.

(3) Receiver processing (such as mathematical rounding and electrical interference) may cause errors that are usually either very small (which may add a few feet of uncertainty into each measurement) or very large (which are easy to detect). Receiver errors are typically on the order of 4 feet.

(4) Conditions that cause signal reflections before the satellite's transmitted signal gets to the receiver can cause small errors in position determination or momentary loss of the GPS signal. While advanced signal processing techniques and sophisticated antenna design are used to minimize this problem, some uncertainty can still be added to a GPS measurement.

(5) A satellite's exact measured orbital parameters (ephemeris data) can contain a small error of approximately 4 feet.

b. System Operation.

(1) The Department of Defense (DOD) is responsible for operating the GPS satellite constellation and constantly monitors the GPS satellites to ensure proper operation. Every satellite's ephemeris data are sent to each satellite for broadcast as part of the data message sent in the GPS signal. The GPS is a system of cartesian earth-centered, earth-fixed coordinates as specified in the DOD World Geodetic System 1984 (WGS-84). Navigation values, such as groundspeed and distance and bearing to a waypoint, are computed from the aircraft's latitude/longitude and the location of the waypoint. Course guidance is usually provided as a linear deviation from the desired track of a Great Circle course between defined waypoints.

(2) GPS navigation capability from the 24 satellite constellation is available 24 hours a day anywhere in the world. GPS status is broadcast as part of the data message transmitted by the satellites. Additionally, system status is planned to be available through Notices to Airmen (NOTAM). Status information is also available by means of a telephone data service from the U.S. Coast Guard. Availability of suitable navigation capability from the satellite constellation is expected to approach 100 percent.

(3) GPS signal integrity monitoring will be provided by the GPS navigation receiver using receiver autonomous integrity monitoring (RAIM). For GPS sensors that provide position data only to an integrated navigation system (e.g., FMS, multisensor navigation system), a level of GPS integrity equivalent to that

of RAIM may be provided by the integrated navigation system. Availability of RAIM capability to meet nonprecision approach requirements in the United States with the 24 satellite constellation is expected to exceed 99 percent.

c. Selective Availability (SA). SA is essentially a method by which DOD can artificially create a significant clock and ephemeris error in the satellites. This feature is designed to deny an enemy nation or terrorist organization the use of precise GPS positioning data. SA is the largest source of error in the GPS system. When SA is active, the DOD guarantees horizontal position accuracy will not be degraded beyond 100 meters 95 percent of the time, and beyond 300 meters 99.99 percent of the time.

d. Portable Units. All portable electronic systems and portable GPS units must be handled in accordance with the provisions of FAR 91.21. The operator of the aircraft must determine that each portable electronic device will not cause interference with the navigation and communications systems of the aircraft on which it is to be used. Portable GPS units which are attached by Velcro tape or hard yoke mount that require an antenna (internally or externally mounted) are considered to be portable electronic devices and are subject to the provisions of FAR 91.21. All portable GPS equipment attached to the aircraft by a mounting device must be installed in an approved manner and in accordance with FAR Part 43. Questions concerning installation should be referred to an avionics or airworthiness inspector. A critical aspect of any GPS installation is the installation of the antenna. Shadowing by the aircraft structure can adversely affect the operation of the GPS equipment. FAA approval of avionic components, including antennas, requires an evaluation of the applicable aircraft certification regulations prior to approval of an installation. The regulations require that the components perform their intended functions and be free of hazards in and of themselves and to other systems as installed. Pilots should be aware that a GPS signal is weak, typically below the value of the background noise. Electrical noise or static in the vicinity of the antenna can adversely affect the performance of the system. It is recommended that system installations be flight tested in conjunction with other navigation equipment prior to using the system for actual navigation. Unless a portable GPS receiver is TSO C-129 approved, it is not to be used as a basis for approval of operations in the NAT MNPS.

e. Navigation Classes. All navigation performed in flight is either Class I or Class II navigation.

(1) Class I navigation: Any en route flight operation or portion of a flight operation conducted in an area entirely within the officially designated operational service volumes of ICAO standard airways navigation facilities (VOR, VOR/DME, NDB). The two generic types of Class I navigation are navigation by direct reference to ICAO standard navaids and navigation by use of area navigation systems.

(2) Class II navigation: Any operation or portion of an en route operation which takes place outside (beyond) the officially designated operational service volumes of ICAO standard navaids (VOR, VOR/DME, NDB). Any en route flight operation or portion of a flight operation which is not Class I navigation. There are three generic classes of Class II navigation. These are navigation by reference to ICAO standard navaids supplemented by dead reckoning, navigation by use of pilot-operated electronic long-range navigation systems (e.g. INS, Omega, GPS), and navigation by use of a flight navigator.

f. RAIM. A technique whereby a civil GPS receiver/processor determines the integrity of the GPS navigation signals using only GPS signals or GPS signals augmented with altitude. This determination is achieved by a consistency check among a series of satellites being tracked. At least one satellite in addition to those required for navigation must be in view for the receiver to perform the RAIM function.

g. Supplemental Air Navigation System. An FAA-approved navigation system that can be used in addition to a required means of air navigation. May be used as the primary navigation system provided an operational approved alternate means of navigation suitable for the route of flight is installed on the aircraft.

h. System Availability. The percentage of time (specified as 98 percent) that at least 21 of the 24 satellites must be operational and providing a usable navigation signal.

9. FAA APPROVAL OF GPS EQUIPMENT.

a. GPS Equipment Classes. GPS equipment is categorized into classes A(), B(), and C() (ref. TSO-C129).

(1) Class A(). Equipment incorporating both the GPS sensor and navigation capability. This equipment incorporates RAIM.

- Class A1 equipment includes en route, terminal, and nonprecision approach navigation capability.
- Class A2 equipment includes en route and terminal navigation capability only.

(2) Class B(). Equipment consisting of a GPS sensor that provides data to an integrated navigation system (i.e., flight management system, multi-sensor navigation system, etc.).

- Class B1 equipment includes RAIM and provides en route, terminal, and nonprecision approach capability.
- Class B2 equipment includes RAIM and provides en route and terminal capability only.
- Class B3 equipment requires the integrated navigation system to provide a level of GPS integrity equivalent to RAIM and provides en route, terminal, and nonprecision approach capability.
- Class B4 equipment requires the integrated navigation system to provide a level of GPS integrity equivalent to RAIM and provides en route and terminal capability only.

(3) Class C(). Equipment consisting of a GPS sensor that provides data to an integrated navigation system (i.e., flight management system, multi-sensor navigation system, etc.), which provides enhanced guidance to an autopilot or flight director in order to reduce flight technical error. Installation of Class C() equipment is limited to aircraft approved under FAR Part 121 or equivalent criteria.

- Class C1 equipment includes RAIM and provides en route, terminal, and nonprecision approach capability.
- Class C2 equipment includes RAIM and provides en route and terminal capability only.
- Class C3 equipment requires the integrated navigation system to provide a level of GPS integrity equivalent to RAIM and provides en route, terminal, and nonprecision approach capability.
- Class C4 equipment requires the integrated navigation system to provide a level of GPS integrity equivalent to RAIM and provides en route and terminal capability only.

NOTE: Operators requiring additional GPS approval information are referred to the following AC's: AC 20-130, "Airworthiness Approval of Multi-Sensor Navigation Systems for Use in the U.S. National Airspace System (NAS) and Alaska," and AC 20-XXX, "Airworthiness Approval of Global Positioning System (GPS) Navigation Equipment for Use as a VFR and IFR Supplemental Navigation System" (This AC was formerly FAA Notice N8110.47).

b. Approval Criteria. A GPS installation with a TSO C-129 authorized navigation system in Class A1, A2, B1, B2, C1, or C2 may be used in combination with other approved LRNS for unrestricted operations in NAT MNPS airspace or may be used as the sole means of long-range navigation on the special routes that have been developed for aircraft equipped with only one LRNS and on the special routes developed for aircraft equipped with short-range navigation equipment. The basic integrity for these operations must be provided by RAIM or an equivalent method. A single GPS installation in Class A1, A2, B1, B2, C1, or C2 which provides RAIM for integrity monitoring may also be used on those short oceanic routes which have only one required means of long-range navigation.

c. Avionics. Documentation must be provided which validates approval of the installed GPS airborne receiver in accordance with Notices 8110.47, 8110.48, AC 20-129 and AC 20-130A, as appropriate, or other applicable airworthiness criteria established for GPS installations. When it has been established that the airborne system has been certified for GPS IFR operations, the following criteria should be used to determine the operational suitability of airborne systems for GPS IFR use:

(1) Initial Installations and Continued Airworthiness. The operator must ensure that the equipment is properly installed and maintained. No special requirements, other than the standard practices currently applicable to navigation or landing systems, have been identified that are unique to GPS, e.g., Airworthiness Directives, Service Bulletins.

(2) Action. Aviation safety inspectors must evaluate installation (An avionics inspector should evaluate the avionics installation and recommend the approval prior to the issuance of an LOA to operate in NAT MNPS airspace.), crew capabilities, and operational responsibilities relative to GPS oceanic operations prior to issuing an LOA for operation in MNPS. Specific items to check are as follows:

(a) The GPS navigation equipment used must be approved in accordance with the requirements specified in TSO C-129 and the installation must be made in accordance with Notice 8110.47 or 8110.48 or the AFS/AIR joint guidance memorandum dated July 20, 1992.

(b) The basic integrity for these operations must be provided by RAIM or an equivalent method.

(c) The GPS operation must be conducted in accordance with the FAA-approved flight manual or flight manual supplement, if required.

(d) Aircraft using GPS equipment under IFR must be equipped with an approved and operational alternate means of navigation appropriate to the route to be flown. This traditional navigation equipment must be actively used by the flightcrew to monitor the performance of the GPS system.

(e) Procedures must be established for use in the event that significant GPS navigation outages are predicted to occur. In situations where this is encountered, the flight must rely on other approved equipment, delay departure, or cancel the flight.

(f) Aircraft navigating by GPS are considered to be RNAV aircraft. Therefore, the appropriate equipment suffix must be included in the ATC flight plan.

10. GPS OPERATIONS SPECIFICATIONS.

Air carrier operators planning on utilizing GPS are required to have their operations specifications amended prior to performing operations utilizing GPS. The specific operations specifications items that must be considered are as follows:

- En Route authorization for class I navigation.
- En Route authorization for class II navigation using a single GPS.
- En Route authorization for class II navigation using GPS and a second Long Range Navigation System.
- Authorization for use of GPS in Central East Pacific (CEPAC) Airspace.
- Authorization for use of GPS in Northern Pacific (NOPAC) Airspace.
- Authorization for use of GPS in North Atlantic MNPS Airspace.
- Authorization to conduct operations in Areas of Magnetic Unreliability with GPS.
- Authorization for use of GPS to conduct Nonprecision Instrument Approach Procedures in Airplanes.
- Authorization for use of GPS to conduct Nonprecision Instrument Approach Procedures in Rotorcraft.

Approaches using GPS equipment are subject to the following limitations:

(1) The GPS equipment used must be approved for IFR operations, including nonprecision approaches, and the GPS constellation and the required airborne equipment must be providing the levels of accuracy, continuity and integrity required for that operation.

(2) The flightcrew must have successfully completed the approved training program and demonstrated competency in these operations.